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NOT TO BE TAKEN INTO FRONT-LINE TRENCHES

NOTES ON FIRE ON AEROPLANES

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General.

WAR DEPARTMENT,
WASHINGTON, *August 27, 1917.*

The following Notes on Fire on Aeroplanes are published for the information of all concerned.

[062.22, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

H. L. SCOTT,
Major General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
Washington, June 19, 1917.

To all officers of the Army:

[redacted] come.

By order of the Secretary of War:

H. P. McCAIN,
The Adjutant General.

CONTENTS.

NOTES ON FIRE ON AEROPLANES.

ANTI-AIRCRAFT 75 MM. GUN.

PROVISIONAL FIRING INSTRUCTIONS.

August 15, 1916.

These instructions take the place of instructions No. 1, issued December 24, 1915, and changes No. 1, dated February 27, 1916.

Instructions No. 2 will remain in force except when they conflict with the present instructions and until they are replaced by the Provisional Regulations for the automobile gun and the gun on the platform mount, which are being prepared.

TABLE OF CONTENTS.

CHAPTER I.

FIRE AGAINST AN AERIAL TARGET ASSUMED TO BE FIXED.

1. In field fire the trajectory of the 75 mm. gun is assumed to be rigid.

In the high-angle fire this hypothesis leads to great error. Tables I and II (not available to observers) indicate that the "fuse-setter range," that is to say the fuse setting, and the angle of departure do not depend solely on the range, but that they also depend on the altitude of the target or, which amounts to the same thing, to its angle of site.

FUSE-SETTER RANGE.

2. The "fuse-setter range" is the range at which the fuse setter must be marked in order that the fuse may be punched at the desired point.

It is obtained directly by the operator at the altitude telemeter (see Chapter IV) when that instrument is marked in fuse-setter ranges.

But when the instrument is graduated in true ranges and not in fuse-setter ranges it is necessary to take the following precautions:

(1) Fix as limiting fuse-setter ranges (using the 30/55 fuse):

Altitude in meters.	True range.
9,000 to 2,000	8,500
8,500 to 3,000	8,000
8,000 to 4,000	[1] 7,500

As soon as these limits are exceeded the range does not materially change and the time of flight becomes very inconvenient.

(2) For altitudes above 2,500 meters, for shrapnel armed with the 30/55 fuse, from 6,000 meters on, increase the altitude 50 meters each time that the range as read increases 1,000 meters.

For the high-explosive shell, armed with the 24/31 fuse (initial velocity, 570 meters), make the following changes in the altitude, regardless of the range:

15 mils for altitude 2,000 meters.
20 mils for altitude 2,500 meters.
25 mils for altitude 3,000 meters.
30 mils for altitude 3,500 meters.
35 mils for altitude 4,000 meters.

In all other cases disregard the difference between the fuse-setter range and the true range.

SIGHT ELEVATION.

3. The range at which the projectile bursts is determined by the fuse setting. The fuse having been punched, this can not be changed.[2] In contradistinction to that which takes

[1] These and the following figures are provisional only, pending the result of the experiments undertaken to determine the trajectories.

[2] Limited to a small zone near the target, the surface of equal settings ("équi-évent"), which corresponds to the setting given, appears as a portion of a sphere.

place in percussion field fire, the sight elevation does not change the range but influences only the point of burst. For this reason the sight elevation to be given is that which will have the greatest number of chances of making the projectile burst at the point desired above the line of site of the target.

This angle depends upon the point at which the fuse has been set—that is to say, upon the fuse-setter range—and upon the angle of site.

In most of the matériel in service this angle is given automatically by the sight scale.

In matériel not equipped with a sight graduated in mils, the sight elevation is obtained from a table. (See Ch. VIII.)

In both cases the elevation must correspond to the fuse-setting, even if that is assumed to be incorrect.

In using another sight elevation the range of burst is not changed and a false height of burst is obtained.

NORMAL HEIGHT OF BURST.

4. The fuse setter is equipped with a corrector.

The corrector setting which has the greatest chance of obtaining bursts in the plane of sight is—

Corrector 10 when the fuse setter for 30/55 fuses is used.
Corrector 17 when the fuse setter for 22/31 fuses is used.

In certain cases the corrector may be adjusted by fire for adjustment (see Ch. IV), but the corrector must not be changed during fire. If there is a discrepancy between the fuse setter and the sight this should be corrected by means of the angle of site. (See Ch. V.)

AEROPLANES.

5. *Shrapnel.*—On account of the depth of the cone of dispersion it is desirable to adjust the burst a little above the plane of site at a height which is called the "normal height of burst," and which depends upon the target. Expressed in mils, the normal height of burst is 5 mils up to 7,000 meters and 10 mils from there on. Expressed in divisions of the corrector, it is always four divisions. (NOTE.—One division of the corrector has the following values: 1 mil at 3,000, 2 mils at 6,000, 2 to 3 mils at 8,000.) For this reason the proper corrector to adopt is—

14 for the 30/55 fuse.
21 for the 22/31 fuse.

High-explosive shell.—It should be well understood that the normal height of burst is zero.

DIRIGIBLES.

In fire against dirigibles the center of the target should always be the point aimed at.

As a matter of principle, tracer shells should be used. If none are on hand, use high explosive or shrapnel. Whatever type of projectile is used, take the following as a normal corrector:

10 with the 30/55 fuse.
17 with the 22/31 fuse.

Attempt to adjust the height of burst just above the center of the target.

CHAPTER II.

CORRECTIONS BASED ON THE MOVEMENT OF THE TARGET.

CORRECTION OF THE HEIGHT OF BURST.

5. This depends upon the target and upon the remaining velocity of the shrapnel balls in the cone of dispersion. The effective cone will be deeper and the normal height of burst higher in the case of an aeroplane which is approaching than in the case of one which is retiring.

In such cases the normal heights of burst given in the preceding chapter should be modified as follows:

Increase by 3 to 4 mils for an approaching aeroplane;

Diminish by the same amounts for a retiring aeroplane.

On account of the great number of causes which affect the height of burst (see Chapter V), the above precaution need only be taken as advising a tendency to fire a little high or a little low, depending upon the direction of the target.

DEFLECTION, SITE, AND RANGE CORRECTIONS.

(The velocity of the wind being assumed as zero.)

6. When the piece is layed on the initial position of the target A_0, it is necessary to make a *deflection correction* and a *site correction* such that the shrapnel balls will arrive at the "set forward point" A, or future position of the target, at the same

instant as the target. These corrections are based on the travel of the target during time of flight.

The fuse-setter range having been estimated or measured, it is necessary to give it to the fuse setter to set the fuse, to load, and to fire, and in order that the projectile may hit the target, to make a range correction which takes into consideration the time lost in serving the piece O and the time of flight T.

These corrections are based on estimates or measurements made before fire. For this reason it is necessary to make an assumption in regard to the speed and the direction of the aeroplane, not only during the service of the piece (range correction) but also during the time of flight (range, deflection, and site corrections). As soon as the fuse is set the range can not

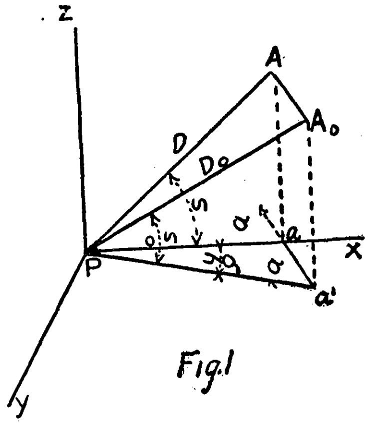

Fig. 1

be changed. As soon as the shot is fired nothing can be done to change the deflection and the site. Moreover, the aeroplane is free to change speed or direction. Chance plays a very important part in this kind of fire.

DEFLECTION AND SITE CORRECTIONS.

7. The piece being assumed to be laid on the "set forward point" A:

The *deflection correction* is the angular displacement which must be set off on the sight for direction so that it may be directed upon the "original position" A_0.

The *site correction* is the angular displacement which must be set off on the sight for elevation in order to bring it on the "original position" A_0.

The methods to be used depend upon the instruments available.

(*a*) In case there is no instrument available to measure the speed of the target, it is necessary to base the methods on an estimation of the orientation and speed.

(*b*) In case an altitude tachoscope is available (d'Arnouville type) or a similar instrument giving the speed, methods depending upon orientation and the measurement of the speed are used.

(*c*) In case instruments are available which can be used to measure the angular speeds both in direction and elevation from which the deflection and site corrections can be taken automatically. This is known as the tachometric method.

NOTE.—The following symbols are used in the formulæ:

- V Speed of the target, or the speed of the target in conjunction with that of the air, which, for present uses, may be considered as the true speed.
- h The altitude of the target.
- α_0 Angle made by its symmetrical axis with the vertical plane of sight or the "angle of present orientation."
- α Angle made by the symmetrical axis of the target with the plane of fire or the "angle of future orientation."
- D_0 The present range.
- D The future range or the fire range.
- B The future fuse-setter range.
- S_0 The present angle of site.
- s The future angle of site.
- t_0 The time of flight depending upon the present range, D_0.
- t The time of flight depending upon the fire range, D.

The following formulæ assume that the altitude, the speed, and the direction of the target remain the same during the time of flight. But in every case they remain true only in case the average speed in the path A_0–A, as seen in perspective in the plane of the future altitude is designated by V, and in case the angle made by the line of sight with the perspective of AA in the horizontal plane is designated by α_0.

DEFLECTION CORRECTIONS.

PLATFORM MOUNT, MODEL 1915.

The axle of rotation of the sight is nearly perpendicular to the initial plane of site.

The deflection correction may be expressed as—

$$\delta = \frac{V t \sin \alpha_0}{D} \text{ [1]}$$

AUTOMOBILE MOUNT.

The axis of the telescopic sight is vertical. The deflection correction in the horizontal plane is expressed as—

$$\delta_h = \frac{V\ t}{D \cos s} \sin \alpha_0 = \frac{V\ t}{\sqrt{D^2 - h^2}} \sin \alpha_0 \text{ [2]}$$

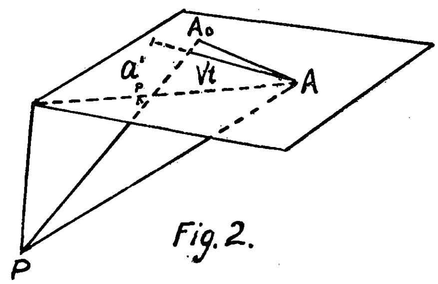

Fig. 2.

SITE CORRECTIONS.

PLATFORM MOUNT, MODEL 1895.

The axis of rotation of the plane of sight is perpendicular to the plane of fire (independent elevating mechanism), or, in the case of the sight with variable settings with site corrector, it is nearly perpendicular.

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[1] The exact formula is:

$$\sin \delta = \frac{V t \sin_0 \alpha}{D} \frac{\text{Cos } S_0}{\cos S}$$

[2] The exact formula is:

$$\sin \delta_h = \frac{V\ t}{\sqrt{D^2 - h^2}} \sin \alpha_0$$

The site correction may be expressed as

$$\sigma = \frac{Vth}{DD_o} \cos \alpha$$ [1]

AUTOMOBILE MOUNT.

The movement which is given to the prism of the sight in order to make the plane of sight of A coincide with A_o consists of:

(a) A rotation around a vertical axis (deflection correction) which, in theory, changes neither the position of the prism in its seat nor the line of sight.

(b) A rotation of the same prism around the horizontal axis of its cylindrical seat which causes the initial angle of site to coincide with the future angle of site.

The site correction $h = s - s_o$ [2] may be expressed by the following approximate formula:

$$\sigma_h = \frac{Vth}{DD_o} \cos \frac{\alpha + \alpha_o}{2}$$

The corrections δ, σ, δ_h, and σ are expressed as functions of the four principal variables, which are—

The orientation α_o,
The fuse-setter range B.
The intrinsic speed V, and
The altitude h.

The determination of these elements will be discussed in Chapter IV.

The observation of the orientation and the range should be continuous.

---

[1] The exact formula for the independent elevating mechanism is:

$$\sin \sigma = \frac{Vth}{DD_o} \frac{\cos \alpha}{\cos \delta}$$

[2] Accurately speaking the formula is $\sigma_h = s - s_o + \epsilon$. ϵ being the error due to the transmission of the sight dial. When s is in the neighborhood of 37°, the error ϵ is nearly zero.

The angle $s - s_o$ may be expressed by the formula:

$$\sin (s - s_o) = \frac{Vth}{DD_o} \frac{\cos \frac{\alpha + \alpha_o}{2}}{\cos \frac{\alpha - \alpha_o}{2}}$$

The angle ϵ is expressed by the formula;

$$\epsilon = \frac{\delta^2 h}{2} \sin (s_o - 37°)$$

The intrinsic speed and the altitude vary but very slowly. These elements may be considered as the *invariables*, since they remain invariable during the time of flight if not during the entire series. As soon as these elements are known the deflection and site corrections are given in the following manner.

8. *Sights provided with the d'Arnouville goniometer and sitometer.*—In order to correct the deflection or the site it is necessary to set off on the same instrument the appropriate speed, the altitude, the fuse-setter range, and the orientation. Having done this the required direction may be given to the sight. The speed and the altitude ordered are given exactly. With the platform goniometer the altitude is given in multiples of 500. For all the goniometers and sitometers it is sufficient to give the range to the nearest 500 meters. The distance between the curves of orientation will indicate the degree of precision which should be sought in giving the orientation.

(Observer's note: A "conjugateur," as used in (*a*), paragraph 8, is a kind of sight, but the simple word "sight" is hardly descriptive enough.)

SIGHTS GRADUATED IN MILS.

(*a*) Some stations are provided with an anti-aircraft "conjugateur" based on the principle of the "cone of pointing," which will be explained in paragraph 27. The elements used are the speed and the altitude. The orientation is automatically corrected in the laying. The deflection correction, the site correction, and the future range are read directly.

(*b*) Other stations are provided with goniometers and sitometers independent of the gun. According to the instructions furnished with each instrument, the deflection may be read directly.

(*c*) Still other stations have nothing except the tables. The table which most closely agrees with the speed and altitude commanded is used and the correction is obtained at the intersection of the columns for "range" and "orientation."

ESTIMATED SPEED AND MEASURED SPEED—DIFFERENCES BETWEEN THE METHODS.

9. *Estimated speed.*—The speed is estimated according to the model of the aeroplane. But even though that estimation may be correct the shots will not be correct for deflection unless they are also correct for range. "Shorts" will burst before the

passage of the target and will be seen in front of it, while "overs" will burst after its passage and be seen behind it. (Fig. 3.) In both cases the bursts will have a displacement parallel to the axis of the aeroplane. An error of one-tenth in the range involves an angular displacement equal to A_oPA, that is an apparent error in deflection equal to one-tenth of the correction of the site. Unless this range error exceeds 500 or 600 meters the displacement will remain very slight. In cases in which this error is exceeded adjustment will be very complicated. These complications will be explained in Chapter V. They involve the necessity of devising a means for measuring the altitude accurately.

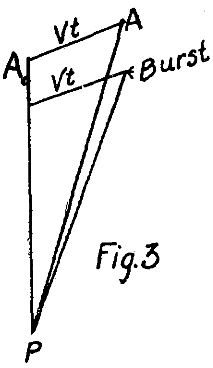

Fig. 3

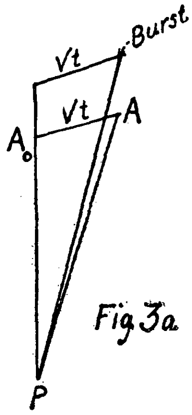

Fig. 3a.

Measured speed.—The speed which it is essential to measure (see Chapter IV) is not the speed V, but the speed seen in the perspective in the plane of the altitude in which one fires. (See fig. 4.) This fictitious speed V_t must be marked on the instruments used in order that bursts may be properly adjusted for deflection and height. If the speed is thus measured, errors in range will have no effect on displacements in deflection and height. On the contrary, when the altitude is changed at the gun and the aeroplane remains at the same altitude, it is necessary to change the speed in the same sense. (See Chapter IV.) If this is not done, the deflection will become faulty.

USE OF THE TACHOMETER.

10. The four variables as functions of which these corrections are expressed are:

The altitude h, or the site s.

The fuse-setter range B,

The angular speed of rotation in the vertical plane of sight ωd.

The angular speed of the line of site in vertical plane of sight ωs.

These angular speeds are expressed as follows:

$$\omega d=\frac{V\sin\alpha_0}{D_0\cos s_0}\quad \omega s=\frac{Vh}{D_0 2}\cos\alpha_0.$$

In multiplying them by t, which depends only on B and on h, there is obtained an approximate value of the deflection correction in the horizontal plane as well as a site correction.

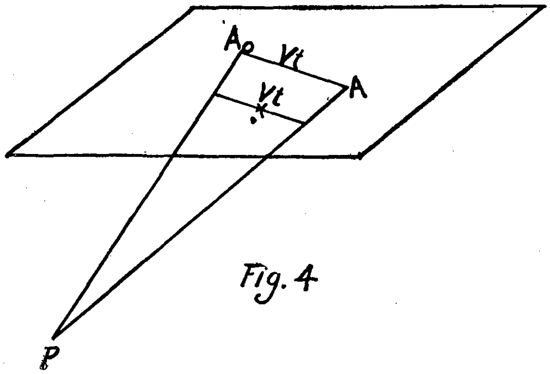

Fig. 4

The accurate formulas are as follows:

$$\sin\delta h=\omega d^t\frac{D_0\cos s_0}{D\cos s}=\omega d^t\frac{\sin\alpha}{\sin\alpha_0}$$

$$\sin\delta h=\omega s^t\frac{D_0}{D\cos\alpha_0}\,\frac{\cos\frac{\alpha+\alpha_0}{2}}{\cos\frac{\alpha-\alpha_0}{2}}$$

In the service instruments this multiplication is made automatically and the error made is also automatically taken into

consideration. Detailed instructions for their use are furnished with each instrument.

11. *Range corrections.*—The determination of the corrected range, that is to say, the future range, will be taken up amongst other subjects in Chapter IV.

CHAPTER III.

SECONDARY DEFLECTION AND SIGHT CORRECTIONS.

12. The corrections referred to as "secondary corrections" are due to wind, to drift, and to constant lack of adjustment of the lines of sight.

The total correction necessary due to these causes is made in different ways, depending upon the instruments and matériel available.

GONIOMETERS AND SITOGONIOMETERS.

Whether these instruments are attached to the carriage, or are independent of it, they are provided with a "movable zero," or "movable origin," by means of which the algebraic sum of the secondary corrections and the corrections due to the travel of the target may be set off. By exception, the sitogoniometer of the independent sighting device of the model 1915 platform mount is not provided with a movable zero, and the secondary corrections are set off on the deflection scale of the sight with the origin at 100.

THE USE OF TABLES.

Tables are used when the instruments are not provided with a movable zero.

The drift correction is included in the correction due to the travel of the target and need not be considered here.

It is necessary to add the total of the other secondary corrections to the corrections due to the travel of the target and to handle them in such a way that the addition may be easy. (See the Regulations.) Many stations, however, have provided themselves with improvised movable zeros.

WIND.

13. When there is a wind there is a difference between the intrinsic speed of the target and the actual speed, and the angle of orientation also varies by the angle which the path of the target makes with the line of sight. The wind correction

is not, however, made according to the V and the α_0 which enter into the formulas of Chapter II, representing the intrinsic speed and the orientation or the actual speed and the angle of the path of the target.

Methods based on the intrinsic speed.—Deflection and site corrections are based upon the displacement of the aeroplane caused by the resistance of the air. The wind affects both the aeroplane and the projectile, but the aeroplane is affected more than the projectile.

It is necessary to place the shots on the side toward which the wind is carrying the target. For a 10-meter per second cross-wind the correction for the platform mount is, roughly, 25 mils. In this case the deflection is taken in the plane of site. For the automobile mount, in which the deflection is taken in the horizontal plane, the correction is 30 mils for long ranges (low angle of site) and 50 mils for short ranges (high angle of site). For a wind up or down the range the correction to be made for a 10-meter per second wind is about 10 mils, regardless of the mount used.

Methods based on the actual speed.—Not only methods based on the actual speed and the angle of the path of the target but also the tachometric method must be understood. Deflection and site corrections consider only the actual path of the target. The action of the wind on the projectile is disregarded. The following practical rule applies to the case:

(*a*) Do not touch the height.[1]

(*b*) For deflection, place the shots on the side from which the wind is coming (the reverse of the preceding method).

(*c*) The correction varies with the range.

(*d*) For a 10 meter per second cross wind, the corrections are:

5 mils at 3,000.
10 mils at 5,000.
15 mils at 8,000.

Influence of changes of direction of the target.—The following symbols are used:

W=the velocity of the wind.

φ=the angle made by the direction of the wind with the plane of fire.

---

[1] In order to be exact, it is necessary to place the bursts on the side from which the wind is coming. The correction will be about 5 mils for a 10 meter per second wind up or down the range.

No matter what method is used, the transverse component of the wind varies proportionally with the sign of φ, and the longitudinal component of the wind varies proportionally with the cosine of φ. It is thus seen that the wind corrections depend upon the azimuth of the target.

In order to take this into consideration, prepare for different values of W a series of charts like Tables III and IV. (These tables not available.—Observer.) Properly oriented these charts divide the space into a series of zones, in each one of which the corrections may be considered as constant.

The officer conducting fire or a cannoneer detailed for the purpose reads the initial correction from the chart. The methods of fire depend upon the accuracy with which the velocity of the wind is known. If the velocity is not accurately known, the continuous nature of the adjustment is depended upon, and corrections are made according to the amount of observed errors. If the velocity of the wind is accurately known, an attempt is made to correct errors before they become evident. In order to do this the cannoneer reads the corrections from his chart, depending upon the azimuth of the target. He commands changes of 5 mils in the proper sense each time that the target changes direction. (Certain stations have improvised an indicator needle which moves with the gun and indicates the corrections. This method is particularly recommended.) As we shall see later, the velocity of the wind is never accurately known unless it is determined just before the opening of fire. The cannoneer detailed for the above duty may also perhaps be required to total all the other secondary corrections and to announce this total at each instant in order that it may set off on the instruments.

14. *Drift.*—Drift is little understood. To correct it, the deflection should be increased as follows:

Model 1915 platform automobile mount:

Range		Mils.
5,000 / 6,000	5	5
6,500 / 7,000	10	10
8,000 / 8,500	15	15

These corrections are already made in the tables, and need cause the personnel no concern.

The goniometer does not correct the drift; but it may be adjusted so that the drift is allowed for at ranges between 6,000 and 7,000 meters.

15. *Adjustment of lines of sight.*—The lines of sight must be verified with the greatest care. If the verification indicates a considerable constant error, the sights must be reassembled in such a way as to correct it. If the position of the sights can not be changed easily, the error must be allowed for in the total of the secondary corrections.

Chapter IV.

DETERMINATION OF THE ELEMENTS OF THE FIRE DATA.

NOTE.—The details concerning the way in which the various instruments are to be used are given in the instructions which are sent out with them. Only the principles are explained here.

GENERAL PROVISIONS.

16. If the target were fixed and there was no wind, the only element of the data to be determined would be the fuse setting—that is to say, the fuse-setter range. The elevation which will give this range is obtained automatically from the sight scale. (Chapter I.) But since the target is mobile it is necessary that this fuse-setter range correspond not to the actual but to the future range of the target. The determination of the future fuse-setter range implies, generally, the determination of the altitude also. The future fuse-setter range and the altitude being known, the site and deflection corrections are then dependent upon three elements, viz:

(*a*) Either the intrinsic orientation and intrinsic speed, or

(*b*) The true path of the target and the actual speed, or

(*c*) The angular speed of displacement in the horizontal and vertical planes.

The only remaining elements are the secondary corrections, which have been discussed in Chapter III and which imply a knowledge of the velocity of the wind. The best method of determining it is to fire a series of trial shots. In that case the adjustment is made much easier, because the trial shots determine the *corrections of the day.*

ALTITUDE AND RANGE.

17. *Importance of the altitude.*—In order to determine the future fuse-setter range it is necessary to make an hypothesis as to the travel of the target during the time T, which is the sum of the time of flight t and the lost time due to the service of the piece Θ. Unless something is known to the contrary,[1] it is assumed that the altitude does not vary during T. This hypothesis permits the design of instruments of continuous measurement, which are simple and economical and which are employed without reference to the distant observer.

Since the future altitude h is assumed to be the same as the actual altitude at the time it is measured, the actual altitude only need be measured. The instrument which measures the altitude is called the altimeter.

This instrument gives the altitude by the formula:

$$D=\frac{h}{\sin\ s}$$

The future fuse-setter range is given by the empirical formula obtained from the range tables, $B=t\ (h.s)$.

In order, then, to deduce either D or B it is only necessary to know the future s.

The problem of the determination of the future site has been solved for the gun. (Chapter II.) The future sight is obtained by direct sighting with a site correction. This site correction Σ will be greater than that of the gun on account of the lost time due to the service of the piece. The range will be obtained by a very simple instrument called the *altitude telemeter with site correction.* Diagrammatically the instrument is shown in figure 5.

It consists of the following essentials:

(a) A scale $o\ a'$ which is directed upon A', which is the position of the target Θ seconds before the firing of the shot. This scale measures the actual site, s'.

(b) A scale oa by which it is possible to set off the site correction Σ with respect to oa', and which registers the site of the future position of the target A.

(c) A horizontal cross hair ef, whose position above zero represents the altitude of the target according to the scale of the instrument.

[1] That is, unless an altimeter is on hand which is precise enough to give the most probable "future altitude."

The future range is read either at the intersection of the scale *oa* and the cross hair *ef*, or upon the scale itself, which would be the true range, or upon a chart of equal fuse settings, which would be the fuse-setter range.

The altitude is introduced not only because by its determination the future fuse-setter range may be obtained, but because, since it varies very slowly, it is not necessary to determine it in an absolutely continuous manner; and also because in substituting it for the range, an element which can not be reduced to rules on account of its enormous variations, we obtain an element which can almost be reduced to rules even when the instrument which gives it has ceased to function. When a variable element is measured continuously by an instrument the instrument may be adjusted. But only the elements which vary very slowly can be regulated except by accurate measurement.

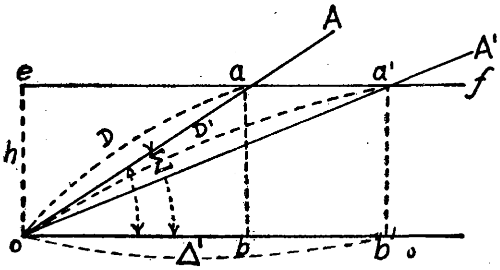

Fig 5

Under such conditions the altitude telemeter becomes the best instrument for the conduct of fire. The altitude is set off on the instrument from time to time, and the future fuse-setter ranges are read from it continuously. If the ranges then appear faulty they may be corrected by correcting the altitude.

The details based on the foregoing principles are as follows:

ALTIMETERS.

18. The altitude telemeter which has been explained diagrammatically registers on $o\ a'$ the actual D' of the target A'. It registers on $O\ b'$ the horizontal distance $\triangle'$, the horizontal projection of D' and on $a'\ b'$ the altitude h.

But since $o\ a'$ is constantly directed on the target it is necessary to know only one of the sides of the right triangle $o\ a'\ b'$ in order to deduce the others. Thus, in order to know the altitude, it is not necessary to measure it directly, because only $\triangle'$ or D' need be measured.

Direct altimeters give the altitude directly. Indirect altimeters, depending on the type employed, measure either the actual horizontal distance $\triangle'$ or the true distance D'. In order to obtain the altitude, such instruments must be completed by altitude telemeters. Direct altimeters are evidently much to be preferred.

DIRECT ALTIMETERS.

19. The regulation altimeter (Puteaux type) is a long-base altimeter based on the principle shown in figure 6. Let $P\ O$

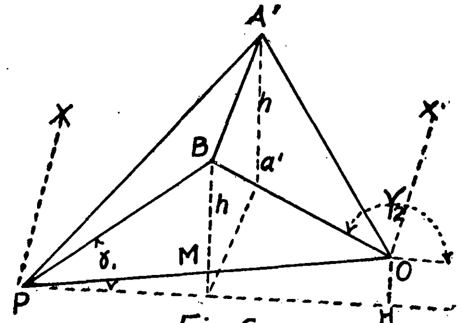

Fig. 6.

be the base, A' the aeroplane, B its projection in the vertical plane passing through $P\ O$. The altitude of A' is the same as that of B. This being the case, if the triangle $P\ B\ O$ and the horizontal $P\ H$ are materialized according to scale, the altitude of the aeroplane will be given by the distance from the point B to the line $P\ H$.

The base b and the angle $H\ P\ O$, the inclination of the base being known, it is only necessary to construct the triangle to know the two angles γ_1 and γ_2.

To this end two planes of sight are established through P and O, movable around two horizontal arms, passing, respectively, through P and O and perpendicular to $P\ O$. These two

planes are directed on the aeroplane A', and the angles which they make with the horizontal plane are measured. These angles have the values γ_1 and γ_2. The accuracy of the instrument is approximately proportionate to its base, and is greatest when the target is near M, the center of the base $P\ O$. With a Puteaux type altimeter in good adjustment,[1] with a base of 3,000 meters, the altitude of an aeroplane flying in the zone of action of the battery may be measured within an average error of 1/50 if the following precautions are taken:

Assembling.—The perpendicularity on $P\ O$ of the arms $P\ x$ and $O\ x'$ must be assured within about 50 millièmes. The parallelism and horizontality of the two arms, the horizontality

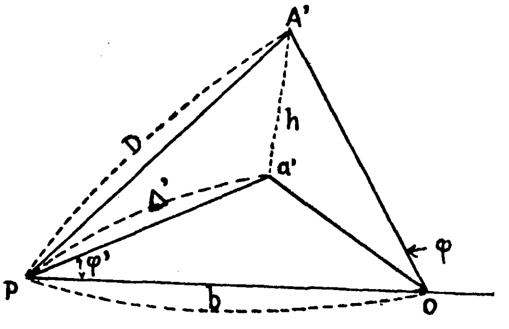

Fig 7

of the two lines (zero lines) between which are measured the angles γ_1 and γ_2 must be assured within about 5 millièmes.

Employment.—Unless the operator deviates from the aeroplane by more than 2 or 3 mils, an error in pointing is not important, but the two observations must be simultaneous within one second.

INDIRECT ALTIMETERS.

20. *Telemeter of horizontal distance* (fig. 7).—At P and O are placed two azimuth circles by means of which it is possible to measure at each instant the angles ϕ and ϕ_2 and thus to construct or to calculate the triangle $P'a'O^2$ the horizontal

[1] Instructions on the altimeter explain the methods of verifying the adjustment.

projection of $P\ A'\ O$. In the majority of stations the azimuth circle which measures the angle is the altitude telemeter itself. $\triangle'$ being known, it is possible to deduce h, either by means of the altitude telemeter or by the multiplication of $\triangle'$ by tgs', s' being the angle of site A' read on the altitude telemeter.

Accuracy.—For an aeroplane at battle ranges the determination of $\triangle'$ will be of little value unless the angles ϕ_1 and ϕ_2 are both large. The instrument is of no use when the aeroplane approaches the base too closely. This fact is another evidence of the superiority of the direct altimeter. It can not equal the direct altimeter unless there are several well placed stations. In a zone favorable and with a 3,000-meter base an average error of less than 1/50 is obtained if the instrument is in adjustment and the following precautions are taken:

Assembling and employment.—The absolute orientation of each observation post within 5 mils and not the relative orientation, as in the case of the direct altimeter, is essential. The two axes of rotation must be vertical within an error of about 5 mils. The error in pointing must be less than 2 or 3 mils. The observations must be taken simultaneously within a quarter of a second. (As compared with one second for the direct altimeter.)

TELEMETERS FOR TRUE RANGE.

21. The only regulation instrument is a single-observation instrument, the Barr and Stroud. If it is in good order and well adjusted, good range observation up to 6,000 may be obtained with this instrument, but it is not satisfactory for long ranges. Most of the improvised long-base altimeters are superior. This instrument should be used only when better ones are lacking, and then only to determine the altitude of departure. It should be noted that if this instrument has been adjusted upon a distant point on the horizon the constant errors will be great for large angles of site.

IMPROVISED ALTIMETERS.

22. There are several improvised altimeters. Some are based on the principle explained in paragraph 9. The altimeter known as the "thread altimeter" is particularly recommended. If it is well assembled it should give very accurate results.

Others are based upon telemeters of the horizontal distance and present the same inconveniences. One of the best of the

other types is known as the "altimeter of perspective plane."

23. *Estimation.*—When no altimeter is available an estimation of the altitude corrected by adjustment during fire must be depended upon; but this should be a last resort; and all stations must use their best efforts to establish the means by which they can measure the altitude of aeroplanes quickly, accurately, and in a continuous manner.

ALTITUDE TELEMETERS.

24. As has been explained before, the altitude telemeter is the best instrument for the conduct of fire. The regulation instrument, known as the field telemeter, is based on the principle set forth in paragraph 17, but its altitude graduation is carried on an alidade which registers the angle *s*. This alidade is equipped with a true altitude slide, on which is placed another slide called the "ballistic corrector." The instrument includes a "site corrector," which will be explained in the next paragraph.

25. The site correction of the altitude telemeter is equal to the difference between the future site s and the actual site s'. It is expressed by a formula similar to that which applies to the site of the gun on the automobile mount:

$$\Sigma = V\frac{T}{D}\sin s' \cos\frac{\alpha+\alpha'}{2}$$

The exact formula is as follows:

$$\sin\Sigma = \frac{VT}{D}\sin s' \frac{\cos\frac{\alpha+\alpha'}{2}}{\cos\frac{\alpha-\alpha'}{2}}$$

$T=t+\Theta$, being the time of flight increased by the time lost in the service of the piece, α being the angle of orientation measured Θ seconds before fire.

This correction is calculated and used by one of the following methods:

(*a*) By means of a telemeter fitted with the d'Arnouville automatic corrector, called the "Snail corrector" (Correcteur à Limacon). The speed and the orientation may be set off on the corrector, and the alidade is then given the proper setting.

(*b*) By means of a field telemeter with nonautomatic corrector. In this case the correction is read either on the inde-

pendent sitogonimeter, or by means of the appropriate double-entry table, or by means of a voltmeter or similar instrument. This is called the tachometric method.

The tables may be considerably simplified because, when the range is small, or, to speak more precisely, when the angle of site is great, a large error in the site correction is not important because the range read on the telemeter will not be affected by it in any appreciable way.

This fact permits the number of lines in each table to be reduced. The same fact permits the use of old-model telemeters, in which the graduations do not exceed 120 mils in each direction. In general, when the correction is greater than this, it is because the site is very great and it is not necessary to give an exact correction.

26. *Ballistic corrector.*—If the range were not affected by the conditions of the day, or even by the conditions of the hour, if all the telemeters were graduated in fuse-setter ranges, if the site correction was always correct, an error in range would be an indication of an error in altitude, and it would only be necessary to set off the true altitude on the altitude telemeter in order to obtain an effective range. But, in reality, the altitude which must be set off on the altitude telemeter in order to obtain an effective range is a fictitious altitude called the "ballistic altitude." The difference between the time altitude and the ballistic altitude is called the "ballistic error" or the "ballistic correction." The observation of the ballistic error is made with reference to a given position of the aeroplane which is always a past position.

In order to deduce from the observed difference the "future difference," which applies to the future position, it is necessary to make an hypothesis. It is best to assume, as in field fire, that ballistic errors in range are nearly proportional to the range, and that the ballistic errors in altitude are constant. On these facts are based the idea of registering the ballistic error separately by means of a ballistic corrector.

It should be well understood, however, that this registration will have no value unless the true altitude is measured continuously. Under any other conditions it is impossible to separate the true altitude from the ballistic altitude. Based on the above principles the following rules for the use of ballistic corrector have been deduced:

PRACTICAL RULES.

(*a*) When there is a continuous measurement of the altitude—

The altitude should be measured by the altimeter on the true altitude slide.

The corrections made during adjustment should be registered on the ballistic altitude slide.

(*b*) When a continuous altitude measurement is impossible—

Both slides are used, the true altitude slide being used for large corrections and the ballistic altitude slide being used for small corrections.

All readings are given to the officer conducting fire. The first altitude measurement is communicated as follows: "Altitude ———."

If the fire is already well adjusted, the officer conducting fire pays no attention to the altitude reported.

At each new altitude measured the observer at the altimeter announces: "Altitude ——— more, or ——— less." This indication is given only to the officer conducting fire, who takes it into consideration or not, depending upon circumstances.

As will be seen in Chapter V, paragraphs 64–68, if range observations are being obtained regularly, the altitude observations are useless repetitions and must not be retained except as indications of the inclination of the path of the target. If, on the contrary, range observations are not being received, the information from the altimeter is depended upon entirely.

The observer at the telemeter should be instructed to send the new ballistic altitude to the canoneers supervising the service of the piece and eventually to the observer who measures the speed each time that the altitude changes by either 100 or 200 meters, depending upon whether the tachometer or the sitogonimeter is being used.

ALTITUDE TELEMETER WITHOUT SITE OR BALLISTIC CORRECTOR.

27. This telemeter, which is still in use at several antiaircraft stations, gives the actual range of the target. The fuse-setter range must be taken from tables which to be of real value should be constructed as follows:

(*a*) They should give the altitudes varying by 400 meters;

(*b*) The speeds of the target varying by 5 meters per second; and

(*c*) The orientations varying by 15°.

In order to give (*c*), the tables have to be more complicated than similar tables giving the site correction. Tables giving the future range must be deduced from others giving the site correction Σ by means of the following nearly exact formula:

$$\frac{D--l}{D_0}=\Sigma \quad \text{Cotg}\, s=\frac{\Sigma^2}{2}$$

which gives D_0 as a function of D. The term Σ^2 may perhaps be disregarded. The ranges thus obtained are the true ranges. It is necessary to add algebraically the corrections necessary to obtain fuse-setter ranges.

In order to avoid the use of such complicated tables the stations should—

(*a*) Take steps to provide themselves with the altitude telemeter with an improvised site correction; or

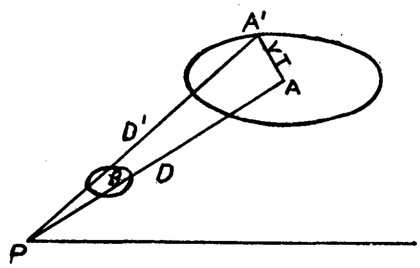

Fig. 8

(*b*) Take steps to provide themselves with a pointing wheel based on the following principle:

Principle of the pointing wheel.—The point A being given, and the wind assumed to be zero, the locus of the point A' is a horizontal circle with A as the center and VT the radius. (See fig. 8.) The circle and the point P determine a cone called the "cone of pointing." The normal line of sight of the telemeter, such as is used for a fixed target, should be directed on the future position A. In order to direct it on A' it is necessary to shift the line of sight by an angle equal to APA'. That is to say, it is necessary to move the line of sight about the pointing cone so that the direction $A'A$ is in prolongation of that of the target.

The cone of pointing may be materialized by means of a point of sight P and a horizontal pointing wheel or a horizontal turnstile (pointing turnstile) with a radius equal to r. The wheel or turnstile has its axis in the normal line of sight at a distance equal to l—Pa from the pointer P such that

$$\frac{r}{l}=\frac{VT}{D}$$

The proportion $\frac{T}{D}=\frac{t\theta}{D}$ is practically constant and has a value of $\frac{4.9}{1000}$.

The term $\frac{r}{1}$ depends then only on V.

The pointing wheel may be employed to lay the gun both in deflection and for elevation; but the term $\frac{T}{D}$ should be replaced by $\frac{t}{d}$, which is not at all constant.

It is necessary to replace the speed graduation, of which we shall speak later, by a scale of speed ranges. The pointing wheel is mounted on a fork whose base slides on a scale graduated in speeds.

Since the elevation of the telemeter is the only important factor, there is some advantage in replacing the point P by a horizontal wire mounted in a fork. The plane of sight is determined by the horizontal wire and the point on the circumference of the wheel which corresponds to the angle of orientation given. If the orientation may be determined by the naked eye, the target should be seen entering the wheel with its axis pointed toward the center and its wings tangent to the circumference of the circle. For low rates of speeds (dirigibles) take a half wheel and multiply by 2 the speed to be recorded. The scale should also be given a greater length.

28. *Altitude telemeter on cradle of automobile mount.*—At the moment the reading is taken the site recorded by the cradle is equal to $s'+\sigma$, and to $s'+\Sigma$. This results in an error which is corrected by replacing the index of the altitude slide by a rack with five teeth, the space between teeth being equal to 90 mils of altitude. (For greater precision, substitute a rack with three teeth, which will be discussed in Chapter VI, on a slide which is moved by a normal slide over a scale graduated in orientations.)

The outside teeth are not used except in fire by series. (See par. 74.)

When the orientation of the target corresponds to $\pm 90°$ or to $\pm 75°$, the range to be read corresponds to the center tooth. For other orientations the following rules apply:

If the target is approaching, read the upper tooth.

If the target is retiring, read the lower tooth.

This is not an exact method, but in the most unfavorable cases, when the orientation is $\pm 60°$, the range error will not exceed 100 meters, and it is usually less.

29. *Secondary corrections on the altitude telemeter.*—The secondary site corrections concern—

(*a*) Lack of adjustment of the line of sight. It is necessary to have the axis of the telemeter vertical. It is further necessary to see that the site of the plane of sight is registered exactly on the dial which carries the site graduations. This double verification should be made by sighting on two points in opposite direction whose correct angles of site are known. If the constant error is greater than 5 mils, the instrument should be readjusted or the error compensated for by a constant correction.

(*b*) Range corrections. Assuming that the line of sight is adjusted, the only site corrections to make are corrections due to the displacement of the target. (See Chapter V.) In the case of adjusting by altitude (see Chapter V again) the secondary corrections—that is, adjustment corrections and wind corrections applied to the gun—are registered on the site corrector of the telemeter.

Secondary altitude corrections.—The altitude corrections made on account of wind are:

(*a*) *Adjustment by the range.*—Amongst the methods based on the intrinsic speed are:

(1) Place the bursts on the side toward which the wind is blowing the aeroplane; that is to say, lengthen the range if the wind is blowing " down the range " and shorten the range in the opposite case. Expressed in terms of altitude changes, the correction to make is about 50 meters for a wind of 10 meters per second up or down the range.

If the correction is based on the actual speed, make similar corrections but in the opposite sense.

(*b*) *Adjustment by the altitude.*—As far as the intrinsic speed is concerned, the corrections made to the gun, and thus to the

telemeter, will correct the influence of the wind sufficiently. If the correction is based on the actual speed no site correction is made on the gun. (See par. 13.) Then apply the same rule as for the adjustment by the range.

ORIENTATION AND INTRINSIC SPEED.

30. *Orientation.*—The orientation may be either measured or estimated.

(*a*) *The d'Arnouville telescope.*—This is the regulation telescope, which serves both for reconnaissance and for the measurement of angles. It is based on the principle of the apparent angle which the plane PA_0F makes with the vertical plane of A_0F being the direction of its axis, the apparent angle γ_0 is the angle which the plane PA_0F makes with the vertical plane of

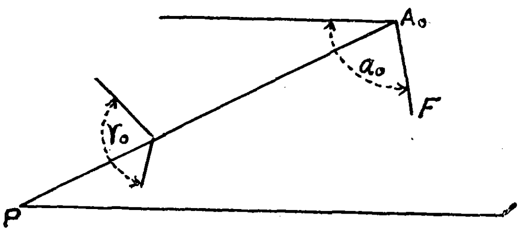

Fig. 9

sight. It is the angle α_0 seen in perspective on a plane perpendicular to $P\ A_0$. The angle α_0 has with the angle γ_0 the relation expressed $1\,g\,\alpha_0 = t\,g\,\gamma_0 \sin s_0$. That is to say that it is sufficient to measure γ_0 and s_0 to deduce α_0.

The axis of the telescope is directed constantly on the target and registers the angle s_0. The telescope is also turned around its axis so that the cross hair is constantly directed on the fuselage of the target. The angle through which it is turned is the angle γ_0. A scale on the instrument gives the angle α_0. A special graduation makes it possible to obtain α_0 by turning the cross hair toward the wings of the aeroplane. When the aeroplane is moving on a straight line and when its orientation is in the vicinity of 90°, the accuracy obtained by basing this measurement on the wings is a little greater than the accuracy obtained when the axis of the target is used.

(*b*) *Estimation by field glasses or the eye.*—Experience shows that an ability to estimate the orientation of aeroplanes may be acquired very quickly by daily exercises with actual or miniature aeroplanes. These exercises consist in comparing the estimates made with instrumental measurements of the actual orientation. All officers, noncommissioned officers, and certain selected privates amongst the specialists should be so trained.

In the beginning an attempt is made to estimate the angle made between the axis of the aeroplane and the wings. These angles ψ and ψ' are simply the "apparent angles" made with the horizontal and are, with relation to the angle, expressed by the formula:

$$\frac{tg\psi'}{tg\psi}=tg^2\alpha_0$$

The orientation is thus seen to be determined by the relation between the apparent angles. If the relation between the smallest and the greatest is considered they will be found to be as follows:

0 for angles of orientation 0 and $\pm 90°$.
1/14 for angles of orientation $\pm 15°$ and $\pm 75°$.
1/3 for angle of orientation $\pm 30°$ and $\pm 60°$.
1 for angle of orientation $\pm 45°$.

If the model of the aeroplane is known information may be had from the way in which the tail projects over the wings; but rules based thereon are good for one model of aeroplane only.

The estimation by field glasses or the eye of the orientation of a dirigible can not be accurate. Instrumental measurement is absolutely necessary—either an angle measuring instrument or an improvised wheel such as will be described in paragraph 33.

31. *Intrinsic speed.*—The intrinsic speed may be either measured or estimated.

(*a*) *Posts equipped with the d'Arnouville tachometer or similar instrument.*—If the wind is assumed to be known, and if the altitude has been measured, the tachometer will give the intrinsic speed. If the altitude has not been measured, the speed is estimated, and the tachometer gives the altitude of departure. The fire for adjustment serves to correct the speed and with it the altitude. If the wind is not known the tachometer can give only the actual speed.

(*b*) *Posts not equipped with speed-measuring instruments.*—Posts equipped with speed-measuring devices will note carefully the speed of aeroplanes measured at times when the wind and altitude are accurately known. These results will be consolidated by armies or groups of armies and will be shown graphically in tables showing the average speed for each type of aeroplane at each altitude. These average results will be communicated to all posts.

ANGLE OF PATH AND ACTUAL SPEED.

32. Experienced officers may estimate with a satisfactory degree of precision the orientation and the intrinsic speed. The estimation of the orientation is instantaneous. In most cases in which the aeroplane flies horizontally its intrinsic speed remains constant and can be more or less correctly judged. (See Chapter V.)

But the angle of path and actual speed can not be properly estimated. It is necessary to have a continuous measurement of these elements. For this reason methods based upon the angle of route and the actual speed are not authorized for posts not equipped with suitable instruments. These instruments have the advantage of being very accessible and of minimizing the uncertainty involved by the wind.

33. *Measurement of the angle of path.*—(*a*) The d'Arnouville telescope. Point and orient the instrument in such a way that when the instrument is left immobile the target will seem to travel along the cross hairs. The angle of path will then be read on the graduated circle.

(*b*) *Improvised turnstile.*—Stretch a horizontal wire across a turnstile. With the eye immobile turn the instrument so that the target follows the cross hair. It is then only necessary to measure the angle made by the plane of sight and the wire. This can be done in many ways which are easy to improvise. For example, the angle of path may be read directly on the surface of a cylinder which is turned by the turnstile and graduated every 15°; or the plane of sight may be materialized and the angle of path read on a graduated disk actuated by the turnstile; or the direction of the path may be recorded on a graduated plate at the foot of the altitude telemeter on which may be read continuously the difference between the azimuth of the path and the azimuth of the plane of sight, the difference being evidently the angle of path.

The improvised turnstile serves equally well for the measurement of the orientation of dirigibles.

34. *Measurement of actual speed.*—(*a*) d'Arnouville altitude tachometer, or similar instrument. This instrument measures the perspective of the actual speed in the plane of estimated altitude. That is to say, the fictitious speed which is essential if the deflection is to be correct. (See par. 9.)

(*b*) *Improvised tachometer.*—When the only requirement of an altitude tachometer is that it should give the actual speed it is possible to simplify it so that it becomes only a horizontal

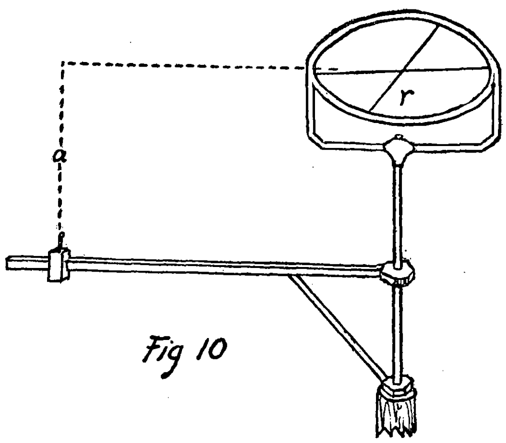

Fig 10

circle with the radius r placed at a constant altitude a beneath the eye. (See fig. 10.)

The time T taken by the aeroplane to leave the circle is measured. The actual speed is given by the formula:

$$\frac{V}{h}=\frac{\frac{r}{a}}{T}$$

which can be solved instantly by a cardboard scale, graduated by hand, and which is something like that described in the Instructions for the Tachometer (fig. 11).[1]

[1] No figure 11 available.

The formula which gives V shows that there is advantage in having $\frac{h}{V}$ as a principal variable instead of V. (See paragraph 7.) Some goniometers and sitogoniometers are graduated in functions of this term; that is to say, in functions of T. A very simple modification permits the use of this term with all goniometers. It is only necessary to mark on the large cylinder opposite the graduations in *log* V a graduation in log $\frac{aT}{r}$. To obtain V it is only necessary to place h opposite T.

ANGULAR SPEEDS OF DISPLACEMENT IN DIRECTION AND HEIGHT.

35. *Tachometric method.*—The target being followed with one or two telescopes, the speed of rotation in azimuth and in site are measured electrically or mechanically. There are always two elements to determine, but those two elements vary constantly and can not be estimated by the eye. It is thus necessary to have rapid and accurate instruments. The tachometers in service fulfill these conditions.

MODIFICATIONS TO BE APPLIED TO ESTIMATED ELEMENTS IN THE CASE WHEN THE PATH OF THE TARGET IS NOT HORIZONTAL.

36. Whatever may be the two elements chosen to define the angular speed and the displacement of the target, viz, the orientation of the intrinsic speed, the angle of path of the actual speed or the angular displacement in direction and height, when these elements are measured, the resulting correction is that which applies to a target flying in a straight line, regardless of all hypotheses based on the constancy of the altitude.

In the method of orientation depending upon measured speed if the route is not horizontal, the d'Arnouville telescope gives the orientation seen in perspective on the horizontal plane which contains the bursts if the cross hair of the telescope is directed on the fuselage and not on the wings of the aeroplane. The tachometer gives the speed seen in perspective in the same plane. If the altitude of fire is the future altitude of the target, the shots will hit the target. Similar reasoning applies to the two other methods; but when the intrinsic speed is estimated the inclination of the path has an influence which must

be known and which depends upon the method in which the orientation is determined. What has been said concerns a slight inclination. If an aeroplane dives suddenly, no matter what the method of fire may be, it must be temporarily interrupted.

First method—Estimated speed with orientation measured by an instrument directed on the fuselage.—The angle of orientation read on the lunette is always the angle of orientation seen in perspective in a horizontal plane. It is necessary to replace the speed V by its perspective in the plane of future altitude. In the case of an approaching aeroplane, the perspective of the same element of its path diminishes when the aeroplane descends and increases when the aeroplane ascends. This fact compensates in part or in whole for the variations in speed. In the case of a retiring aeroplane the two influences are cumulative and it is necessary logically to increase boldly the speed in the case of a descending aeroplane and to diminish it in the case of an ascending aeroplane.

With goniometers and sitogoniometers these momentary changes of speed are made at the indications "Faster ———," or "Slower ———." At this indication each supervisor turns the two cylinders together in such a way that the range index opposite any given range varies from the true range by an amount nearly equal to that which corresponds to the change of speed indicated.

Practically this does not often have to be considered because of its simplicity and because it is impossible to know if an aeroplane which is ascending or descending slowly may not stop ascending or descending at the moment the shot is fired.

Second method—Estimated speed.—Orientation estimated or measured by an instrument directed on the wings. The orientation estimated or measured is that of the horizontal projection of the aeroplane.

The practical rule to be applied would be as follows:

In the case of a descending aeroplane, regardless of its orientation, increase the speed and lower the site.

In the case of an ascending aeroplane diminish the speed and raise the site.

WIND.

37. *Approximate method.*—When there are clouds, the direction of the wind is given by the part of the sky where the

clouds congregate. When a sausage balloon is seen in a direction approximately perpendicular to that of the wind, the apparent angle made by its tail (do not mistake the cable for the tail) with the vertical is equal to its actual inclination, and that actual inclination is a function of the velocity of the wind. In general the inclination goes from 0 to 45 degrees when the velocity of the wind goes from 0 to 15 meters per second.

Under any conditions stations should keep in touch with the Aeronautical Service, which will send them by telephone all information concerning the wind. Such information is of value only when it is used in the same hour in which the measurements were taken. But they are always valuable as a standard of comparison with the standing information given by the sausage balloons.

38. *Accurate method.*—The wind may be determined in an accurate manner by the observation of a smoke ball from a burst at a known altitude. There are two methods:

(*a*) When the direction and velocity of the wind are measured the corrections to be made are deduced from wind tables. For example, establish an improvised tachometer similar to the one described in paragraph 34, but which may perhaps be stronger and better made. An error of one-tenth is of no practical importance, and the height of the wheel of the instrument above the eye needs to be constant only within one-tenth. Set the eye and the instrument so that the smoke ball of a burst may be in the center of the circle. Do not move. Watch the direction taken by the smoke ball. That is the direction of the wind. Measure the time t taken by the smoke ball to leave the circle and deduce the speed of the wind w by the formula:

$$\frac{w}{h}=\frac{\frac{r}{a}}{t}$$

(See par. 34.)

Convenient dimensions are r=.10 meter; a=1 meter;

$$\frac{r}{a}=\frac{1}{10}$$

An intermediate circle with one-half the radius will serve for gentle winds. The time obtained is doubled and there is no need to wait till the smoke ball leaves the larger circle. When the station is equipped with a regulation tachometer or similar instrument, the construction of the instrument will

simplify the process, and the velocity of the wind is obtained directly without calculation.

(*b*) Direct measurement of corrections. Fire a shot in a direction nearly perpendicular to that of the wind and measure the time of flight. Lay on the smoke ball. The difference between the deflection obtained and the correction for drift will give the effect of the wind on the projectile and, accordingly, the deflection correction which will correct for it in methods of fire based on actual speed. Then follow a smoke ball during an interval equal to t the time of flight. The difference between the interval thus measured and the interval previously measured will give the deflection corrections to be made in methods of fire based on the intrinsic speed. It should be understood that the deflections thus measured are good only for the azimuth in which they were measured.

With the deflection correction thus obtained select the table which, when properly oriented, will give for that azimuth and range a correction equal to the deflection correction measured. The selection of this table involves the selection of the suitable table for the site.

In order to orient the table, it is necessary to know accurately the direction of the wind. This is obtained by firing a shot and using one of the methods just described (pointing wheel or turnstile).

The direction of the wind may also be obtained as follows:

The travel of the smoke ball due to the wind is measured in direction and in height, and the measurements obtained are represented by δ and φ respectively. Let φ represent the angle which the direction of the wind makes with the plane of fire. We then have the following formula:

$$tg\ \varphi = \frac{\delta \sin s}{\sigma} = \frac{\delta}{\sigma}\ \frac{h}{D}$$

A rough sketch will give the angle.

39. *Application of the methods described.*—The process described in (*b*) has the advantage of giving the corrections appropriate to the azimuth in a much more accurate manner. It takes into consideration the difference which may exist between the velocity of the wind at the level of the target and at the level of the ground.

The process described in (*a*) has the advantage that it may be applied several seconds before fire, during the fire, or after the fire, as follows:

(1) *A little before fire.*—When an aeroplane is signaled fire a shot short at about 4,000 meters. This will have the double advantage of giving a short time of flight, about 12 seconds, and a high angle of site, which permits a more accurate measurement.

(2) *During the fire.*—Fire is opened with an estimated wind value. During the first few rounds the observer for wind measures the wind, selects the proper table, and reads and announces the corrections to the officer conducting the fire. The officer conducting the fire either disregards or considers these corrections, depending upon whether his fire is well adjusted or not. In either case the last corrections which embody the changes in direction made by the aeroplane are announced at the proper time by the observer for wind.

3. *At the end of the fire.*—Use the last burst to measure the wind, communicate the result to neighboring posts, and record for later use.

COMPLETE UTILIZATION OF TRIAL SHOTS.

40. Trial shots are two or three shots fired primarily for the purpose of determining the wind, and which also serve to determine the corrector for the series, the ballistic correction to be applied to the altitude, and eventually, by tachometric methods, the existing time of flight. One shot is sufficient for the wind; for the corrector, the range, and time of flight at least two are required. A third shot should be fired if any of the results are not consistent.

Trial shots are of little value unless fired just before the opening of fire for adjustment. For this reason they should not be fired in advance, except in cases where the regularity of the arrival of hostile aeroplanes enables the hour of their visit to be known in advance. In other cases wait until an aeroplane coming toward the post is signaled, and then utilize the trial shots as the first ones fired at the target, but do not use them except for the purpose of measuring the wind and if, tachometric methods are available, for the measurement of the time of flight.

In any case all posts which have determined the velocity and direction of the wind should communicate the results to neighboring posts.

In most cases posts communicate to neighboring posts all information on hand in regard to the speed and altitude of an aeroplane which is approaching them.

Trial shots should be fired either in the direction from which hostile aeroplanes are expected, or in a direction nearly perpendicular to the direction of the wind. This latter case is described below.

41. *Wind corrections.* (See pars. 37–39.)

42. *The corrector.*—Fire with corrector 10 for the 30/55 fuse and with corrector 17 for the 22/31 fuse. The shots should burst in the plane of site of the telescope. The plane of site to be used is the revised plane with a constant correction applied on account of any lack of adjustment in the line of sight of the telescope. The error should be disregarded until it is clearly greater than the play in the sights, which should be known to the officer conducting fire.

From the observed error, the corrector correction to be made (14 or 21) is deduced by the following practical rule: One division of the corrector corresponds to 1 mil at 3,000 meters and 2 mils at 6,000 meters.

43. *Ballistic altitude correction.*—Fire at the altitude h_r with the site s and the fuse-setter range B_r read on the altitude telemeter as a function of h_r and s. (With the automobile mount place the slide of the gun telemeter at the altiude h_r.) Move it on the cradle until the altitude telemeter records the range B_r. Set the sight at the same range. With the platform (independent sight) give the gun an elevation equal to the sum of s and the elevation taken from the tables which is a function of s and B_r. Set the sight at the range B_r. (A table at the end of the chapter will give a certain number of combinations—altitude, fuse-setter range, and the elevation for trial shots under normal conditions.)

Measure actual altitude h of a burst. The ballistic altitude correction is equal to $h_r - h$.

There is some advantage in making this a base correction, that is to adopt as a fictitious base for the altimeter a length expressed as follows:

$$b_r = b\frac{h_r}{h}$$

In order to avoid confusion as to the sense of the correction, remember that if the shots are "short"—that is, the altitude is too low—increase the base.

Under the conditions generally governing trial shots (altitude 3,500. range 6,000) the corrector correction will not affect the altitude of the bursts very much, and it is not necessary to consider it.

TIME OF FLIGHT.

44. When the speed is estimated, the errors of the day have the same effect on the time of flight as on errors in the speed. They are eliminated by adjusting the speed. (See par. 56.)

When the speed is measured there is, on the contrary, an advantage in determining the correction of the day for the time of flight.[1]

The time of flight which enters into the formulae for the deflection and site corrections, is the time which elapses between the departure of the projectile and the instant when it passes through the plane of sight. If the trial shots result in a correction of n divisions in the normal corrector, it is necessary to diminish the time of flight as measured by $n+\frac{n}{4}$ tenths of a second.

Such being the case, let t_r be the theoretical time of flight which corresponds to the range B_r and t the measured time of flight including the correction explained above.

Tachometer method.—The instruments in service include a time-of-flight corrector which permits all times of flight to be increased by the ratio $\frac{t}{t_r}$.

Measured speed.—Use the ballistic altitude to calculate the speed; that is to say, the total altitude registered on the telemeter. Modify that altitude by the ratio $\frac{t}{t_r}$. Consider this modification as constant.

No corrections are considered unless they are as great as 3 per cent.

The measure of the time of flight should be made with an accurate chronometer giving quarter seconds, and by an observer who is looking in the part of the sky where the burst is expected.

[1] Observer's note: On account of the fact that atmospheric conditions are likely to change from hour to hour, and not remain constant for the entire day, the term "correction of the day" is not used in the allied armies as much as before the war. The term "atmospheric correction" is considered more accurate.

TRIAL SHOTS.

45. Fire an "aero" shell with the fuse set at corrector 17, range 5,000, elevation 44° 45′, and altitude calculated for a point of burst 3,000. Assume the case of a platform mount equipped with an independent sight for elevation, and a goniometer with a 10-mil deflection correction for drift. The drift correction for 5,000 meters is 6 mils. The correction is perhaps too much by 4 mils in the horizontal plane and nearly 3 mils in the plane of site. The best drift correction is 3. Then give the piece an angle of departure of 44° 45′ and set 5,000 off on the sight, fire when the second hand of a good watch is at zero.

First measurement.—Lay on the bursts. Assume that there has been obtained—

6 for the deflection.
8 for the site.
16 seconds for the time of flight.
2,900 the height of burst measured by the altitude telemeter.

Second measurement.—At the thirty-second second, lay in the direction of the smoke ball. Assume that 34 is the measurement obtained.

Interpretation.—(*a*) Wind: The wind during the time of flight t had an effect on the projectile of $6-(-3)=9$ mils toward the right, and an effect of $34-6=28$ mils on the smoke ball. The wind correction is then in the direction in which the trial shots have been fired.

+10 for the tachometric method (+9 exactly).
—20 for the intrinsic speed method (—19 exactly).

(*b*) The burst is 8 mils low. At the range of the trial shots (5,000) this would involve raising the corrector 5 divisions. The fire should be done with a corrector 26. This correction should not be made until it has been verified by a section burst.

(*c*) Range: An allowance should be made on the base of the telometer in the ratio: $\frac{3000}{2900}$

Or the base may be left as it is and 100 meters added to the ballistic corrector of the altitude telemeter.

46. The table below gives the elevation i for trial shots as functions of the altitude h_r and the fuse-setter range B_r.

Aero shell.

23/31 fuse:

h_r=2,500	B_r=4,000	i=43° 30′
2,500	5,000	38° 55′
2,500	6,000	29°
3,000	4,000	51° 15′
3,000	5,000	44° 45′
3,000	6,000	43° 40′
3,500	5,000	50° 50′
3,500	6,000	48° 15′

30/55 fuse:

h_r=2,550	B_r=5,000	i=40°
2,750	6,000	40°
2,500	3,500	50°
3,100	4,500	50°
3,600	5,500	50°

NOTE.—If the platform is equipped with a sight model 1897 not corrected for drift, the same firing would result in *P. O. T.* 114 at the instant of burst and *P. O. T.* 142 at the end of the time of flight *t*. The interpretation of such a series would be the same as that given in the text.

CHAPTER V.

FIRE FOR ADJUSTMENT.

47. Two general principles dominate these instructions.

First. All observation is of instant application. It should not be like a document which has to be interpreted.

From this fact comes the necessity of analyzing all the causes of error; but in firing as rapidly as it is necessary to fire on an aeroplane, all commands must be spontaneous.

These two apparently contradictory conditions are harmonized as follows:

By an analysis of what has been discussed, by reflection and by daily exercises officers form good mental reflexes. As soon as it is necessary to fire they lay aside complicated reasoning and formulae. They retain only the simplest things in their minds and they permit themselves to be guided by their reflexes, remembering that it is necessary to "let well enough alone."

Moreover, adjustment is very simple if all the measuring instruments mentioned in Chapter IV are available.

Second. No correction makes itself felt until after an interval of time at least equal to the time of flight. Consequently, until after that interval, it is wise to be very prudent in the interpretation of observations. The first bursts after a correction may be of value but only as confirmations or annulments of previous deductions.

ADJUSTMENT IN DEFLECTION AND HEIGHT.

(An analysis of the causes of error.)

48. Even supposing that—

(*a*) The lines of sight are well adjusted (par. 15),
(*b*) The drift corrected for (par 14), and
(*c*) The errors of personnel negligible, errors in deflection and height may be due to—
(1) The fact that the target has changed its direction or speed during the time of flight;
(2) An error in the angle of orientation;
(3) The effect of the law of errors;
(4) The effect of a lack of correspondence between the sight and the fuze setter causing errors in the height;
(5) The wind; and, in the case when the speed is estimated,
(6) An error in the range,
(7) An error in the speed, or
(8) An error in the time of flight.

In order to appreciate the effects of each one of these causes of error it is advisable to trace on paper what it is convenient to call the "future ellipse."

THE FUTURE ELLIPSE.

49. If thrown in relief without regard to distance at which the fire is conducted the aeroplane and the bursts are projected against the heavens in the same manner as the stars. Seen in perspective in the heavens the path A_0A of the aeroplane starting at A_0 will have a varying length depending upon its direction.

Generally speaking, the locus of the point A—that is, the loci of future positions—is an ellipse. The center is A_0. Its greater axis is expressed by

$$\frac{Vto}{Do}=\sin s_0$$

The foregoing is based on the assumption that there is no wind. If there is a wind, conditions are the same as if the entire future ellipse were carried along by the wind. The aeroplane will come from the point A_0, but, considering its orientation, it will appear as if it were coming from the points A_0, A'_0, A_0 being its vector of displacement due to the wind (Fig. 12). The average values of the small axes of the future

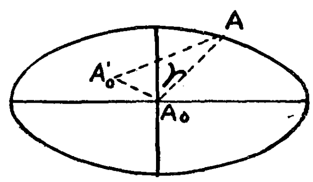

Fig. 12

ellipse are: 120 mils for that which corresponds to the deflection and 70 mils for that which corresponds to the height.

CAUSES OF ERROR.

50. *Change in the travel of the target.*—Figure 13 shows the effect of a change in the travel of the target during the time of flight. The target having been expected at E on the prolongation of the tangent of its path, the shot having been properly calculated, the burst occurs at E but the target is at A. Eliminating the error caused by an appreciable change in the angular speed, the error to be expected in such a case will be nearly the value of the longer axis of the ellipse, let us say, 250 mils.

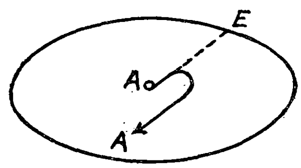

Fig. 13

Lesson.—Pay no attention to errors caused by a change in the direction of the target.

51. *Error in the orientation.*—An error in α_0 is the same as an error in the apparent angle.

Figure 14. A_0E is the displacement estimated, and A_0A the actual displacement. The burst occurs at E instead of at A. It is measured parallel to the wings; that is to say, it is measured in deflection if the target is advancing or retiring at 0 degree, in height if the target is moving at 90 degrees, and partially in deflection and partially in height in the intermediate cases.

The spacing of the curves of orientation of the goniometers and sitogoniometers gives the exact value of the error which results from an error in orientation of 15°.

If the method of estimation is used, at best the orientation can not be determined within 8 or 10 degrees. The error which will occur in the deflection, insignificant when the target is going across the line of fire, increases as its axis approaches

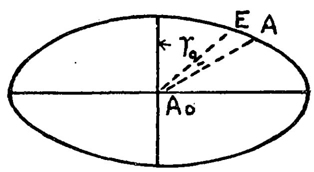

Fig. 14

the plane of fire and may amount to as much as 15 to 20 mils. The error which will occur in the height, insignificant when the angle of orientation is in the neighborhood of zero, becomes very great when it is in the neighborhood of 90° and may amount to as much as 10 mils. But these are accidental errors which may be eliminated if their observation is based on the result of several rounds.

Make decisions only after several rounds is an absolute rule in fire against aircraft.

The use of a telescope to observe the orientation will permit the measurement of the angle within about 5 mils. Errors will then be greatly reduced. Greater accuracy would have no practical value, since the path of the aeroplane is never in an exactly straight line. (It should be understood that a slight change in direction is the same as a slight error in the value of the angle of orientation.)

It is to be noted that the idea of the future ellipse makes it possible to approximate a consideration of the curvature in the path of an aeroplane. It is possible to depend upon an ellipse traced in the field of view of a telescope if that field is as great as 250 mils, or a little outside the field if it is less than 250 mils.

An attempt should be made to determine the point A where the apparent path of the aeroplane meets the future ellipse, and the cross hair of the telescope is directed on the line A_0A. It is assumed that there is not too much wind, in which case there would be confusion between the angle of the path and the angle of orientation.

52. *The effect of the law of errors.*—The dispersion in deflection is small. The dispersion in height is much more important, since it may cause the bursts to vary by 15 to 20 mils in height. The results are the same as for the orientation. The probable error in height does not take into consideration the play in the lines of sight, which amounts to 2 mils at 4,000 and 5 mils at 8,000.

Make decisions only after several rounds. (Not less than three for height.) Take the most careful precautions that the ammunition is stored by lots.

53. *Lack of correspondence between the fuse setter and the sight.*—These errors will in great measure be avoided by firing trial shots (par. 42).

54. *Wind.*—The wind should always be considered. The velocity is determined by one of the methods described in paragraphs 37 and 38. Lacking accurate measurements an estimation may be made, but it is easy to make a mistake of 10 meters per second, and the resulting errors may amount to 20 mils in deflection and 10 mils in height, when the method is based on intrinsic speed, and of about one-third to one-half this amount when the method is based on the actual speed.

55. *Range.*—When the speed is the result of measurement (tachometer or tachoscope, par. 9), the range has no effect on the perspective of the burst, but when the speed is estimated it remains the same whatever may be the error made in range. Accordingly when the burst is short by $n \times 10$ meters, it bursts at E where the target was expected (fig. 15). But the target is not there yet. The perspective of its actual path, which is always equal to Vt is reduced by $n/10$. The target is at A.

The error AE is parallel to the path; that is to say, nearly parallel to the axis of the aeroplane. The error is equal to $n/10$ of A_oE and the locus of A is an ellipse like the future ellipse (fig. 16). (More exactly, the error is $n/10\ A'_oE$.)

Short bursts of 1/10 will be seen as follows:

From 5 to 10 mils high if the target is advancing at "0."

Low from 5 to 10 mils if the target is retiring at "0."

Ten to fifteen mils to the right if the target is retiring at 90 degrees.

In intermediate cases the error will be made partly in deflection and partly in height, the average value of the vector AE being about $1P$ mils.

Lesson (*a*) If the altitude has been measured or if the error of altitude observed does not exceed 200 meters, the error of the burst AE will not exceed 10 mils. It is then disregarded.

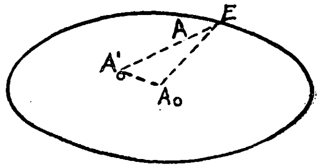

Fig 15

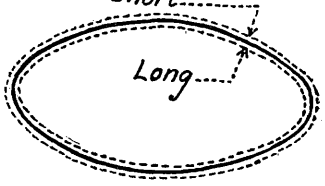

Fig. 16

(*b*) If the range observers signal a large error in altitude there are two things to be considered—

(1) The bursts are signaled "short," but at the gun they are seen "over"; that is to say, behind the target or vice versa. This contradiction is an indication of a gross error and calls for very bold corrections.

(2) The bursts are signaled "short" and at the gun they are seen in front of the target or vice versa.

The range error explains at least in part the error in altitude seen at the guns. A timid correction is called for. In case of doubt no corrections should be made in the hope that the range will correct itself.

(*c*) If the liaison with the distant observers is not working satisfactorily, the errors observed at the battery may be attributed in part to range errors. If the bursts are seen a little ahead of the target, the altitude should be increased. If the

bursts are seen a little behind the target, the altitude should be diminished. This amounts to a sort of adjustment of the altitude by means of the speed, but it can not be considered a precise method. It should be considered as a last resort.

56. *Influence of the speed.*—If the speed has been measured by good instruments in excellent adjustment, any speed errors will be accidental ones and should be disregarded. If the intrinsic speed is estimated for the model of the aeroplane, the error made will rarely exceed 7 or 8 meters per second. The resulting error is easy to calculate.

If too great a speed has been estimated, the bursts will be "short," but the effect is the same.

An error of one-tenth in the speed involves errors in direction and height equal to one-tenth of the deflection and sight

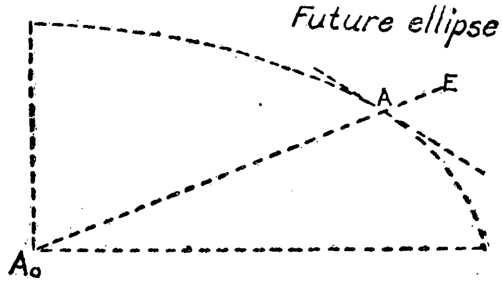

Fig. 17

corrections. The bursts are deflected parallel to the axis of the aeroplane and are transferred to an ellipse outside of the future ellipse (fig. 17) so that the observed errors change in the same way as when the aeroplane makes a half turn. (It should be noted that an error in the intrinsic speed deflects the bursts parallel to the axis, while an error in range deflects the bursts parallel to the path of the target. The difference is too subtle to be of value.)

It is impossible to take this into consideration by a total correction, and the adjustment should be made by the speed itself.

Unfortunately, it is very difficult to distinguish observed errors made on account of a speed error and errors arising from other causes.

Except in very high angles of site, the influence of speed on the height of burst is generally slight. An error of 6 meters per

second in the speed involves an error of height of about 10 mils for orientations in the vicinity of zero and of about 5 mils for orientations in the vicinity of 60 degrees. For orientations between 75 and 90 degrees there is no influence. Considering the many other errors which may cause an observed error in height of burst, it is very exceptional, and only when the sight is very high, that an observed error in height of burst calls for a correction in the speed.

The influence of the speed on the deflection is much greater. An error of 6 meters per second in the speed involves an error of 20 mils for orientations in the vicinity of 90 degrees, 10 mils for orientations in the vicinity of 30 degrees, and is negligible for orientations from zero to 15 degrees. In general if the orientation is close to zero, observed errors in deflection are never to be attributed to the speed nor to the range. From 30 degrees on observed errors may be roughly attributed to two parts. One part is caused by errors other than those in the speed and range and involve a total correction. If the range is correct, the other part may be attributed to the speed. But even for orientations of 75 or 90 degerees such a mistake will never result in an observed error of more than 20 to 25 mils, if the mistake as to speed is from 6 to 8 meters per second. (See par. 59.)

57. *Time of flight.*—The effect of considering the speed too great is the same as that caused by considering the time of flight too great. From this we have the following rules:

If the speed is estimated, the error in the time of flight may be combined with that in the speed, and we can not concern ourselves with it. If the speed is measured, the error is similar to those explained in paragraph 56, but it is more easily corrected. It is only necessary to measure the time of flight in trial shots or during the first shots of the series. With the tachometer the speed is corrected as a result of the measurement of the time of flight. (See par. 44.) With the electric tachometer the resistance of the rheostat should be adjusted as required.

PRACTICAL RULES.

58. *Estimation of observed errors.*—All adjustment depends upon an exact estimation of observed errors.

The aeroplane moves on the average of 5 mils per second. The smoke ball moves much more slowly.

As a result it is essential that the obseravtion should be made in the first second after the burst and that the eye should

travel from the aeroplane to the burst and not from the burst to the aeroplane. Such observations can only be made after careful training and by the exercise of great concentration. A ruler, graduated so that each graduation is equal to one one-hundredth of the average distance from the eye to the hand (with an average angle of site of 30 degrees) will be found useful, but it can not of itself form the accurate spontaneous decisions which are essential.

Assignment to duty.—When the personnel of a station is made up of experienced men it is advisable to confine the adjustment of the height of burst to an assistant, either to an officer, a warrant officer, or a noncommissioned officer. The officer conducting fire should concern himself only with the adjustment of the deflection.

ADJUSTMENT OF THE DEFLECTION.

59. (1) *Case in which the speed is estimated.*—Pay no attention to observed errors which seem to come from changes in the direction. (See par 50.) Make no decisions except after several rounds, especially when the orientation is close to zero.

Briefly, pay attention and do not become hurried. When you have a definite impression that the observed errors are constant, be guided by the following rules:

For orientations from zero to 15 degrees make a combined correction equal to the average of five or six observed errors.

For orientations equal to or greater than 30 degrees take the average of three or four bursts; consider that average as being due to two causes.

(*a*) If the altitude has been signaled as being correct within about 200 meters, one of these causes may be attributed to the wind and all the other influences which must be considered, and indicates the need for a combined correction. The other cause is attributable to the speed. It should not result in observed errors of more than 10 mils for orientations from 30 degrees to 45 degrees and 20 mils for greater orientations. A correction in the speed is called for. (This cause may have no real effect on the error, especially if the velocity of the wind is not well established. That is to say that, strictly speaking, it is just as well to make always combined corrections. But it should be expected that the adjustment thus made will not hold good when the aeroplane makes a decided change in direction.)

(*b*) If the altitude has been signaled as poor, attribute as much of the error to the altitude as seems appropriate and increase or diminish accordingly the correction to be made. (See par. 55.)

(*c*) If the distant observers give no information—

Increase the altitude if the bursts are much in front of the target.

Diminish the altitude if the bursts are far behind the target.

Complete the correction, if necessary, by combined correction.

It should be remembered that the first corrections, once made, are not apparent until the end of 15 to 40 seconds. The first bursts after making a correction should be considered only as confirmation of the errors previously observed.

(2) *Case in which the speed is measured.*—The method is the same as in the case of orientations of small value described above. The adjustment is very simple, and combined corrections only are called for.

Examples: Assume that the speed is estimated and that a platform mount is used.

To open fire.—The aeroplane is reported as "Approaching, angle of orientation 75." Three bursts are observed 30 to 35 mils to the right.

First case.—" Short 400 " is reported (400 meters in altitude).

Officer conducting fire commands: " Increase by 10."

The observed error is interpreted as being due to two causes, as follows: 15 to 20 mils is attributed to the error in range and 10 mils to the error in the combined correction. Since the bursts were in the right sense, with respect to the orientation of the target, the corrections made are timid.

Second case.—The wind, not being well known, " Over 200 " is reported.

Officer conducting fire commands: " Increase by 20; speed 5 less."

The observed error is interpreted as being due to two causes, as follows: 20 mils attributed to the wind, 15 to 20 mils attributed to the speed. The combination results in a bold correction, the bursts being in front, even though " over."

Third case.—" Over 600 " is announced. The officer conducting fire commands: " Increase by 30; speed 10 less." The interpretation is the same as before.

Fourth case.—Lateral communication being interrupted and the wind and speed being considered as well estimated, the command would be: "Altitude 500 more."

ADJUSTMENT FOR HEIGHT.

60. *First case, estimated speed.*—Pay no attention to observed errors which may be due to changes in the direction of the target. In the case of orientation close to 90°, decide only after the observations of several rounds. In brief, pay close attention and do not become hurried. When you have a definite impression that the observed errors are constant, distinguish between the two following cases:

(*a*) Orientations equal or superior to 30° carefully determined: Make a combined correction equal to the observed error.

(*b*) Small angles of orientation: If the altitude is practically correct (within 300 meters), make a combined correction. If the altitude is very incorrect do not make any correction unless the observed error is in the wrong sense; that is to say, if the observed error is behind when the bursts are reported "short" or in front when they are reported "over." In the latter cases make a bold correction.

Inexperienced officers should be careful of the tendency to give low bursts their full value and thus fire too high. In well-adjusted fire a certain proportion of the bursts should be seen below the target.

Second case, measured speed.—The altitude no longer has any importance. The method is the same as for large angles of orientation (combined corrections).

61. *Adjustment of range.*—Bursts being well adjusted for deflection and height of burst, in order to have them effective, it is necessary that they burst slightly "short." That is to say, from zero to 100 meters, or, which amounts to the same thing, it is essential that they burst at about the same height as the target.[1] The word "height" (*hauteur*) is used in its special artillery meaning. Bursts well adjusted for "height" are bursts in the plane of site. In order to avoid confusion when the altitude is being adjusted, the words "high" and

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[1] In order to be well adjusted, to speak exactly, the bursts should be a little high if the range is great, on account of the fact that the target is in the descending branch of the trajectory, or a little low if the range is short, because then the target is in the ascending branch of the trajectory.

"low" ("haut" and "bas") are avoided and the words "short" and "over" are used instead—court and long.

This being the case, in order to adjust the range two methods are employed:

Observation of the altitude.—The difference in altitude between the bursts and the target is measured and the altitude of the telemeter is then corrected. This involves the use of improvised cross hairs.

In order that this adjustment should not be confused with the adjustment in the site, it is necessary that the secondary corrections applied to the angle of site of the gun be also applied to the angle of site of the altitude telemeter. This fact has lead naturally to the automobile mount telemeter in which the telemeter is assembled to the cradle of the gun.

Observation of the range.—The observation of errors in range is made in such a way as to give automatically the correction in altitude which rectifies the range. This is done by the use of knotted cords or the range rake. This adjustment will be independent of the adjustment of the site if one is careful that the secondary corrections are not applied to the altitude telemeter.

ALTITUDE OBSERVATIONS.

62. *Observation of errors in altitude.*—Use of cross hairs in pairs.

Let P be the observer at the battery and O one of the distant observers. Install at both P and O two sets of cross hairs made by stretching horizontal threads perpendicular to the base line and equally spaced. Each one of these instruments is placed at about 1 meter above the eye of the observer. The observers at P and O are said to be "paired" (conjugués) and connected by telephone.

Each observer stations himself under his cross hairs in such a way that he can see the aeroplane as it passes along one of the central wires. At each burst he looks at the cross hairs and sees how many hairs separate the burst from the aeroplane. Each observer records as "short" the bursts which are on the side toward the other observer, and as "long" the bursts which are on the opposite side.

The amount by which the bursts are "over" or "short" is calculated by taking as a standard for the calculation the inter-

val between the cross hairs. Assume that this value is 10 and that the bursts are reported as "Short 40" and "Over 5."

The observer at P receives the estimate from O, adds it algebraically to his own and announces it to the officer conducting fire as "Short 35." The officer conducting fire assumes from this that the bursts are short by three and one-half times the interval between the two wires. (In a similar way when knotted cords are used, the bursts are announced as "Short 4 knots," "Over one-half knot.") Or this interval d corresponds to a correction of altitude Δh, which depends only on the altitude of fire h and which it is easy to know by heart. Let a, being the height of the cross hairs above the eye, and b the base PO, Δh is given by the formula:

$$\Delta h = \frac{d}{b} \; \frac{h^2}{a}$$

That is to say, that Δh is proportional to h^2.

Then if the interval between the cross hairs has been chosen in such a way that Δh shall be equal to 100 meters when h=2,500, Δh will be 200 meters when h=3,500 meters. In the previous example when the bursts were reported as "Short 35," if h=2,500 meters, the bursts are short by 350 meters. If h=3,500 meters the bursts are short by 700 meters, the expression 350 meters and 700 meters "short" meaning that they are at an altitude 350 or 700 meters below that of the aeroplane.

The cross hairs may be built up of five threads stretched perpendicularly to an observation trench parallel to the base line. The threads and the trench should be long enough so that the observer, without leaving the trench, can see the aeroplane following the cross hair.

Alternative procedure.—Instead of placing the cross hairs at a fixed height they may be varied proportionally to the square of the altitude of the target. In this case the interval between the cross hairs corresponds always to the same error in altitude, 200 meters for example. The observers at P and O can in this case calculate themselves the amount by which the bursts seem "short" or "over." This procedure is preferred to the other.

METHOD OF REGISTERING CORRECTIONS ON THE ALTITUDE TELEMETER.

63. *Site corrections.*—It should be well understood that all secondary corrections made on the sights should also be made on the altitude telemeter. Under these conditions the future site $s_0+\sigma$ given to the gun is always nearly the same as the

site $s'\Sigma$ given to the telemeter, and the bursts will be at the correct ballistic altitude h registered on the telemeter, even if there has been a change in the direction of the target during the time of flight. It should be noted that if the change of direction has taken place during the lost time due to the service of the piece Θ. $s_0+\sigma$ may differ considerably from $s'+\Sigma$. There may be several abnormal bursts which need not be considered. (Fig. 18.) (These bursts may generally be identified by the fact that they are markedly incorrect for altitude, but in any case it is easy to see that with the adjustment in altitude the annoying changes in direction are only those which are made before the instant of fire.

Except in cases in which the site correction changes during the time Θ, the equality of the angles s_0+s and $s'+\Sigma$ is par-

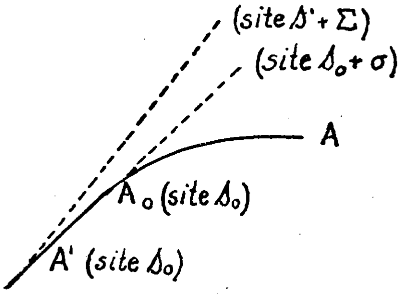


Fig. 18

ticularly well taken advantage of in the altitude telemeter of the automobile mount.

64. *Site corrections.*—If the personnel available does not permit continuous adjustment and continuous measurement of the altitude, there are two courses open:

First method, continuous adjustment.—An attempt is made to measure the altitude before opening fire. The first rounds will indicate the error in the ballistic altitude. This is taken into consideration by the continuous adjustment.

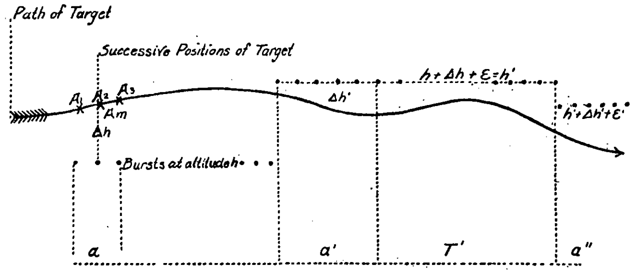
Second method, continuous measurement of altitude.—The true altitude being constantly known, it is sufficient to know the ballistic error. This may be learned either by trial shots or by observing several rounds of actual fire.

If the personnel are available, a third process may be employed which involves at the same time continuous observation and continuous measurement of the altitude.

65. *First method, continuous adjustment* (see chart I).—Let h be the ballistic alitiude used during the fire of the bursts E_1 E_2, and E_3, and Δ^h the average of the observed errors. The altitude $h+\Delta^h$ is that which will give the bursts at the level of the average position $A\ m$. This position $A\ m$ is behind the actual position A_3 by about half the time which separates E_1 and E_3. From this it follows that the averages need not be based on a great number of rounds—3 or 4 for one gun, 7 or 8 for two guns.

If the aeroplane seems to ascend or to descend, the correction Δ^h is changed by an amount ϵ which is estimated by the eye;

CHART No. I CONTINUOUS ADJUSTMENT BY SINGLE ROUNDS



NOTE.—On charts 1, 2, and 3 the times are shown as abscisses and the ballistic altitudes of the aeroplane and of the bursts are shown as ordinates.

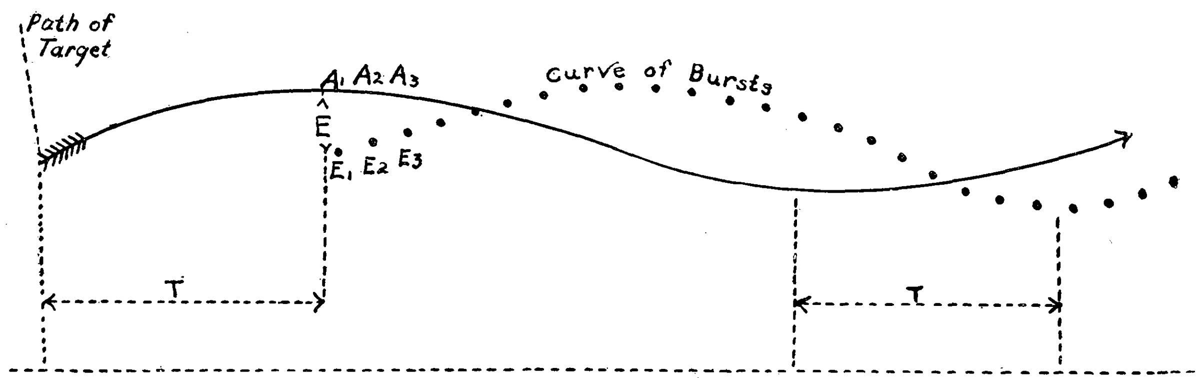
that is to say that the altitude is changed algebraically by $\Delta^h+\epsilon$.

In any case, the correction will not produce any effect until the end of a period of time equal to T. The observations made in this interval should not be made the basis of a correction. They can be used only to confirm the hypothesis made as to the inclination of the path of the aeroplane; that is to say, ϵ.

This period of expectation T will be followed by a period of observation a' which will give the observed error $\Delta^{h\prime}$ from

CHART No. 2

ADJUSTMENT BY SINGLE ROUNDS
EXACT BALLISTIC ERROR
CONTINUOUS MEAUSUREMENT OF
ALTITUDE



rounds fired at the altitude h' $(h+\Delta^h+e)$. An algebraic correction is made to h' equal to $\Delta^{h'}+\epsilon'$.

In this case ϵ' is the new correction due to the angle of the path of the target as well as the following corrections.

To sum up the periods of observation a, a', and a'' are separated by the intervals of time T, T', and T'' during which it is not necessary to consider the observed errors announced except as to the differences they make with the errors observed during the periods of observation.

It should be noted that at the end of the interval T the altitude of the bursts is again equal to $h+\Delta^h+\epsilon$. The value of ϵ being always problematical, it can be said that at that moment the correction of tht altitude is late by the amount of $T+T'+a'$; that is to say, by more than the two times of flight. This inaccuracy of adjustment is one of the reasons in favor of fire by series. (See par. 73.)

66. *Second method, continuous measurement of altitude.*—If the ballistic error has been determined by the observation of several trial rounds, the curve formed by the bursts (chart 2) will be separated from and parallel to the axis of x by an amount equal to T.

It should be noted that the observation of a round does not give the exact ballistic error unless the altitude has remained constant during the time of flight. When the altitude has varied, it is necessary to modify the ballistic error observed by the variation of the true altitude ϵ, which is not practicable.

The continuous measurement of the altitude has the advantage that the altitude at which rounds are fired is never more than the time of flight behind the altitude of the target. On the contrary, since the ballistic error can not be determined except by fire, the measurement of altitude can not be effected by the adjustment, although the adjustment can be effected by the measurement of the altitude.

When several stations are firing on the same aeroplane with the same kind of ammunition, the adjustment becomes impossible and the continuous measurement of altitude is the only means of determining this element. (See par. 78 for details.)

67. *Third method, simultaneous continuous adjustment and continuous measurement of altitude* (chart 3).—The first rounds being observed to burst at E_1, E_2, and E_3 are late by the amount of T_0 (the time of flight plus the lost time due to the service of the piece) according to the measurements made. The average

observed error Δ^h is equal to the algebraic sum of ϵ, the error in the observed error, and ϵ the variation in the true altitude during the time $T_0+\frac{a}{2}$

$$\Delta^h=\epsilon+\epsilon.$$

In adding Δ^h to the altitude $h+6$ announced from the altimeter the error ϵ is twice corrected; that is to say, that it is assumed that the inclination remains the same during the time T as it was during the time T_0. The period T will be an interval during which it is impossible to consider the observations which have any effect on the error, Δ^h. It will be followed by a new period of observation a'. The new error observed Δ^h will be equal to the error made in regard to the inclination of the path of the target and will call for a new total correction, etc.

68. *Case of interrupted measurement of altitude.*—Observation will always indicate the difference Δ^h between the ballistic altitude at which the round was fired and the actual ballistic altitude of the target. (Chart 4.) In adopting $h+\Delta^h$ as the altitude, the future rounds will burst at the level of the position of the target at the moment of observation.

The measurement will give the variation ϵ of the true altitude during the time which has separated the two consecutive measurements. The correction Δ^h has taken into consideration the variation ϵ, which is only considered as an indication of the inclination of the path of the target.

Thus, if the time T is much longer than the time of flight, it is necessary to add ϵ to Δ^h. This assumes that during this single time of flight the change in the level of the target is equal to what it was during the time T. The measurement will then be of no value and it is not necessary to use it.

If the time T is less than the time of flight, it will be advantageous because Δ^h may be increased by the observed error ϵ. But if, during the interval which separates the two observations, two measurements of altitude are received, only the last should be considered. (The sum of the two can be applied to a time $T+T_0$, greater than T_0.) To sum up, each error observed will be increased by the last altitude variation announced, and no other correction should be made.

ADJUSTMENT BY OBSERVATION OF RANGE.

69. *Estimate of the errors in range.*—The cross hairs previously referred to are replaced by knotted cords parallel to the

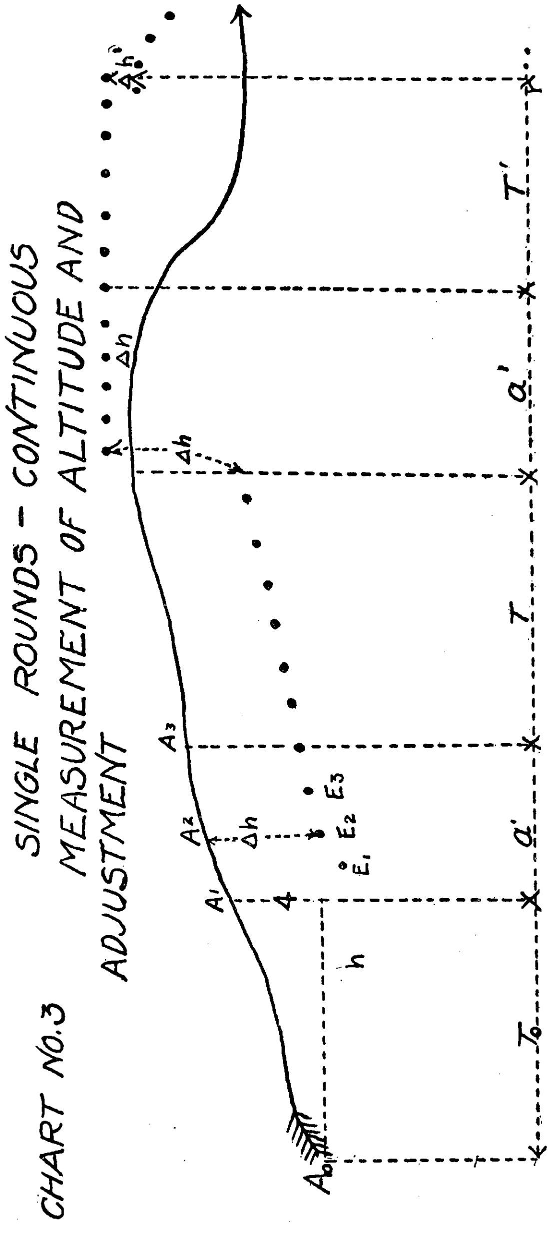
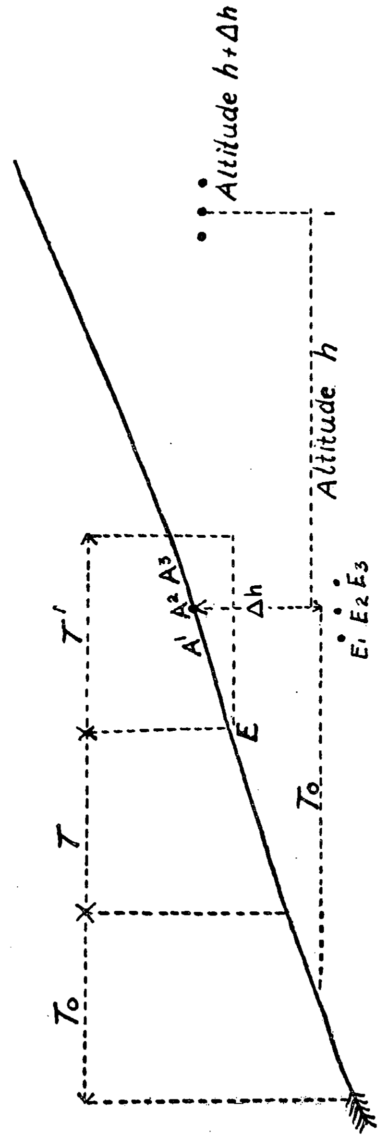


CHART NO.3
SINGLE ROUNDS – CONTINUOUS MEASUREMENT OF ALTITUDE AND ADJUSTMENT
h
Δh
a'
T
T'
T_o

CHART No. 4



base line. The calculation of the height of the cords a and of the interval between the knots d are of assistance to the formulæ given by the cross hairs.

The observed errors are announced by taking the interval between the knots as a basis for the calculation. If the burst is outside of the plane determined by the cord and the target (the plane $P\ O\ A$), the projection of the plane is then considered. If this observation is not made, use is made of a range rake in which the teeth are oriented perpendicularly to the plane $P\ O\ A$ by means of a disk. This process, known as "paired rakes," is considered excellent.

To be absolutely correct the observations at P should be increased algebraically by a per cent equal to $\frac{\sigma \cos \beta}{d}$, β being the angle between PO and PA, considered between 0 and 180. If a rake with corrector is not available, the value of this correction may be estimated. If the angle β is acute, as in the general case, the observer at O will use only the bursts on his replacing $\frac{\sigma \cos \beta}{d}$ by its average value, or, which amounts to the same thing, he increases by one-fifth the interval between the teeth in the battery range rake. The correction will then be automatic.

The number of "knots" or "teeth" or of "meters" which result from the algebraic sum of the average observed errors as announced by P and by O give the corrections to be made on the altimeter in order to establish the range.

REGISTRATION OF CORRECTIONS ON ALTITUDE TELEMETER.

Secondary corrections made on the site of the gun have no effect on the range. In consequence, and as has been shown in paragraph 29, the only site corrections which should be set off on the altitude telemeter are those which correspond to the movement of the target. The altitude corrections are made in the same way as in the case of adjustment by altitude. (See pars. 64 and 68.)

When adjustment by changing the range is employed, all changes in the direction of the target, all errors in the site correction obtained from the telemeter or the altitude are interpreted by means of the range error which has been incorrectly attributed to the error in altitude and which there is necessity

of taking into consideration except when the bursts are not too far off in angle of site.

In a different form this is the same rule which has been given for deflection and height. No attention should be given to errors caused by a change in the direction of the target. On this account adjustment by range is seen to be inferior to adjustment by altitude.

On the contrary the use of the range rake has the advantage over the use of the cross hairs that the teeth of the rake are always perpendicular to the line of sight. This makes observation easier.

The adjustment by altitude is compulsory when the telemeter fixed to the gun is used. The adjustment by the range is recommended for stations which are unable to give to the altitude

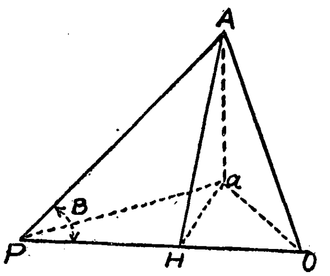


Fig. 19

telemeter the same secondary corrections as the gun itself (movable zero and independent sitogoniometer).

70. *Designation of targets to distant observers.*—In order to direct the eye of the distant observer on the part of the heavens in which the target is expected, it is necessary to give him two indications. First, it is necessary to give him the angle which the plane *P O A* makes with the horizon (see fig. 19). The only secondary consideration which can be sent is an estimation of the altitude or the distance (unless it has been measured by the Barr and Stroud telemeter). From that value is deduced the orientation to be given to the observation instruments at the distant post, by an operation the opposite from that which has given the altitude. If two aeroplanes are in the same part of the sky, the indication, "the highest of the two" or "the

lowest of the two" can be used to identify the one for which the angle $A\ H\ a$ has the greatest or the least value.

During trial shots the same methods are used to indicate the target to the distant observer.

CHAPTER VI.

METHODS OF FIRE.

GENERAL PRINCIPLES.

71. All fire is divided into *fire for adjustment* and *fire for effect*. When firing against aerial targets the adjustment is always approximate, because the orientation, the azimuth, and the altitude of the target is continually changing. It is necessary for this reason to continue the adjustment during all the fire.

It may be assumed that the target will not remain long at a suitable range. For this reason it is necessary to take advantage as soon as possible of everything which may produce effect on the target.

But, in spite of this, the terms "fire for adjustment" and "fire for effect" are still in common use.

Fire for adjustment, or, more exactly, fire by single rounds, is that fire in which each round is fired based on data which has been determined. In fire for effect, or fire by series, a sort of searching fire based on these same elements is employed.

On account of the small volume of fire from anti-aircraft stations, searching fire in altitude only is usually attempted. (Usually anti-aircraft stations have either one or two guns. In cases in which four guns are available, searching in orientation may be attempted.) No searching in deflection nor in height is attempted, and all rounds are fired at the most probable line of future site.

In order to execute searching fire in altitude, the tooth of the altimeter used to read the altitude in the conduct of fire is inclosed by two other metallic teeth. In this way a sort of reading comb is formed (peigne de lecture). The central tooth of the comb gives the altitude announced. By reading the altitude opposite one of the other limiting teeth this altitude is modified by 75 or 100 meters, depending upon the interval

between the teeth which has been adopted. Whatever the method of reading adopted, the fire should be automatic, that is to say, that the ranges are given directly to the fuse setter by the observer on the telemeter at as short an interval as is permitted by the matériel.

The cannoneer on the sight should set off the range which is received from the fuse setter and not that which is received from the altitude telemeter. (See par. 3.)

In order to avoid confusion, the observer on the telemeter announces his ranges in hundreds (" Sixty-four " for " 6,400 ") and the cannoneer on the fuse setter announces the range in meters (sixty-four hundred).

Fire is opened, interrupted, or stopped by the blast of a whistle. The orders " By one " or " By series " indicates the method of fire to be adopted.

72. *Fire by single rounds.*—The observer on the telemeter reads the ranges opposite the middle tooth of the slide. As has been said, fire by single rounds is particularly appropriate for fire for adjustment. The bursts are compared for deflection, height, and altitude, in such a way that conclusions may be drawn from the indications furnished by the observers without knowing to which rounds they apply. (In practice decisions are based on the average of two or three rounds or salvos.) But the aeroplane can not be hit unless its altitude is exactly the same as the altitude predicted. (See charts 1, 2, and 3.)

73. *Fire by series.*—The observer on the telemeter reads successively—

The lower tooth,
The middle tooth, and
The upper tooth; then
The lower tooth,
The middle tooth, and
The upper tooth, and so on.

Theoretically the observed error in altitude of a series is given by the average of three consecutive rounds or salvos. In practice the average of any series is taken. The error involved rarely exceeds 50 meters. Automatically fire by series is well adapted to adjustment. Moreover, it has the added advantage of the possibility of giving effect on the target even though there is a small error in the altitude.

74. *Method with the altitude telemeter of the automobile mount.*—It is necessary to consider the time lost due to the

service of the piece. For that reason the comb of the telemeter is a comb of 5 teeth separated by 90 meters of altitude. In fire by single shots only the three central teeth are used. (See par. 28.) In fire by series, if the direction of the target corresponds to ±90° or ±75°, the ranges opposite the three middle teeth are read. For other orientations, if the target is approaching, the three upper teeth are read; if the target is retiring, the three lower teeth are used.

It should be noted that, expressed in range and not in altitude, the relative depth covered in the fire of a series is proportional to the range.[1] If the interval between the teeth is 100 meters of altitude, the depth covered varies from 300 to 800 meters.

75. *Stations having only an altitude telemeter without corrector.*—In order to avoid the necessity of consulting tables continually fire is conducted as follows:

Diminish by 200 meters the range announced by the observer on the telemeter and fire progressively four rounds, with an interval between them, which depends upon the orientation and the nature of the target, as indicated below:

	Orientation.	Range interval.
(*a*) *Aeroplanes.*—	Approaching 0°	No interval.
	Approaching ±15°	No interval.
	Approaching ±30°	No interval.
	Approaching ±45°	100 meters.
	Approaching ±65°	100 meters.
	Approaching ±75°	100 meters.
	Retiring ±90°	200 meters.
	±75°	200 meters.
	±60°	200 meters.
	±45°	200 meters.
	±30°	300 meters.
	±15°	300 meters.
	0°	300 meters.

(*b*) *Dirigibles.*—Diminish the sight setting by 200 meters at the opening of fire. Fire progressively with a range interval of 100 if the dirigible is approaching and by 200 if the dirigible is retiring.

76. As an exception to the preceding rules, no matter what sort of a telemeter is available, on a retiring target which is

[1] This depth is computed in relation to the three coordinate axes of the aeroplane.

almost to the limit of the range, fire by series of four rounds with range limits as given in paragraph 2.

77. *Choice of methods.*—Great latitude should be given to station commanders in the methods of fire to be used. They should be guided by the following considerations:

There is great advantage in not opening fire except when the altitude has been measured, especially if trial shots have been fired and the opening of fire is delayed a little.

If the distant observer signals "seen," it is best to wait for the measurement; but if he has not seen the target or there is urgent need for the fire, an estimation by the eye is depended upon.

In the first case if the ballastic error has been measured by trial shots, there is advantage in opening fire by series from the beginning. In the other cases the adjustment is made easier if several rounds are fired singly. If there is doubt concerning the altitude, there is advantage in fire with a single piece. Or the fire may be stopped after five or six rounds and the results of observations from distant stations awaited.

78. *One target in the zone of several batteries.*—When several stations fire the same kind of shell against the same target, all adjustment is impossible. Certain precautions are essential unless one wishes the chances of hitting the target to be reduced instead of increased. Under restrictions which will be explained later the following rule will hold good:

"*The target belongs to the first station which fires on it.*"

Therefore, if a target is already under fire from another station, do not fire immediately at it unless ammunition giving an entirely different character of burst is available.

If the opposite course is pursued, combined fire is opened on the aeroplane. In order to accomplish this, two or three trial shots are fired at nearly the altitude of the target, but far enough away from it so as not to interfere with the adjustment of the neighboring station. The altitude and the site of the bursts and the wind are measured. The altitude of the target is then measured, and combined fire is opened upon it by series, the altitude being assured by continuous measurement. (See par. 66, Fire by altimeter.)

The other station is notified by telephone, if possible. In case its adjustment is interfered with, it also resorts to fire by altimeter.

79. *Number of pieces in a battery.*—In combining several guns in the same emplacement, the density of the fire is increased and there are also more men available for direct and lateral observers, altimeter observers, etc. The batteries are less numerous and not so thickly scattered and there is accordingly less danger of confusion during adjustment. But, on the contrary, the stations are thus more easily registered by the enemy, more vulnerable, and there are more empty spaces between the zones covered. The solution of the problem must depend upon circumstances. When there are many pieces in a battery, the commands must be given by telephone, speaking tubes, or by written posted orders.

80. *Choice of emplacements.*—Calculated in horizontal distance, the radius of action of a 75 mm. gun on a platform mount or a section of automobile 75 mm. guns is 7,000 meters for the 30/55 fuse at an altitude of 3,500 meters and 6,000 meters for the 22/31 fuse at the same altitude, not counting the dead zone around the gun, which amounts to a circle with a radius of 1,000 meters for the 75 mm. gun on the platform mount and 1,500 meters for the same gun on the automobile mount.

It is necessary to establish a curtain of fire along the front by placing stations in sets of five, one at each corner of a given square and one in the center; and to defend important places in the rear, the density of fire being dependent upon the importance of the place defended. It follows from paragraph 79 that, once a zone is defended, it is better to increase the density of fire by adding guns to stations rather than to increase the number of stations.

There should not be any hesitation about pushing guns well to the front in order to fire on enemy aeroplanes which are engaged in regulating artillery fire. Experience has shown that this is quite possible provided that the shelters are very strong and well protected from hostile observation. Every precaution should be taken to hide them from sight.

Referring to paragraph 79, it would appear advantageous to place single guns only in advanced posts, even if the supply of guns would permit having more, because when singly placed the guns will obtain more defilade and be less vulnerable.

CHAPTER VII.

USE OF TRACER SHELLS.

81. Tracing shells are designed to destroy dirigibles with flames. The fuse setter used should be the one provided for the 30/55 fuse. The corrector being set at 10, the shell will light 7 seconds after passing the plane of site. It remains lighted and dangerous 14 seconds afterwards. The point at which it lights may be adjusted by changes in the corrector. In lowering the corrector 8 points, the point of illumination is reduced about 1 second in time and 15 mils in angle of site when mid-ranges only are considered.

Seen from the gun or by an observer in the plane of fire the shell appears as a sort of star which shoots to the vertical of the trajectory. Seen by a lateral observer it appears as a star which shoots along the curved trajectory.

While waiting the result of tests now being made, it is assumed that the trajectory of the tracer shell is the same as that of the shrapnel with 30/55 fuse. The same disks for the sight scale and the same tables of corrections apply to it.

82. Fire with tracer shells has the following peculiarities:

(*a*) The correspondence between the fuse-setter range and the sight does not need to be absolutely perfect, and it is thus possible in the case of certain guns designated to fire against dirigibles only to graduate the sight in altitudes.

(*b*) *Adjustment of deflection.*—It is necessary to make an estimate of the error in deflection at the instant at which the shells reach the altitude of the dirigible.

(*c*) *Adjustment of height.*—In principle, without involving any great error, the height of the point of illumination is satisfactory. If by chance the shell, seen *from the gun*, habitually lights the target, or ceases to burn habitually above it, it is necessary to make a bold correction in the corrector of the fuse setter. The angle of site should never be changed except as a result of a movement of the target.

(*d*) *Adjustment of range.*—The trajectory should be observed by means of pairs of knotted cords made visible in any convenient manner. The observers at *P* and *O* are placed so that they may see the dirigible projected against one of the knots. The number of knots on each side of the dirigible should be noted at the time that the trajectory cuts the cord. The

bursts are announced by each observer as "so many knots over" or "so many knots short." The algebraic addition of these two corrections gives the altitude correction to be made on the telemeter.

The observation is good only when the distant observer is far removed from the plane of fire. Hence the necessity of having not less than two distant observers.

When there are two guns at a station, if a visible cord is not available, it is possible to fire the first few salvos with the guns echeloned at 400 meters in altitude in order to establish in the sky a base for observation.

Approximate adjustment.—The distant observer reports the bursts "over" or "short," depending upon whether the dirigible projects itself at the interior or exterior of the trajectory. Only the bursts in which the deflection is not too erroneous should be considered. Several observers are always necessary.

83. *Remarks on the conduct of fire.*—In principle the bursts are always well adjusted for site; that is to say, that the dangerous part of the trajectory is always across the plane of site. If they are well adjusted for deflection and they do not hit the dirigible, it may be assumed that the altitude is wrong.

Lacking information as to the position of the dirigible with respect to the trajectory, it is not advisable to remain always at the same altitude, but it is advisable to search the probable zone in which the dirigible is assumed to be by a series echeloned in altitude.

It should be noted that the tracer shells painted red are slightly more visible than the others. In order to have an idea of the altitude a few shells without rings are mixed with the others. If these are not on hand fire shrapnel with one of the guns.

Chapter VIII.

IMPROVISED MATÉRIEL.

TABLES WHICH MAY BE USED IN PLACE OF INSTRUMENTS.

84. Stations not equipped with all the regulation instruments should provide themselves with improvised ones.

85. *Determination of fire data.*—The intrinsic orientation and speed can be estimated by the eye. The principle upon which

can be constructed improvised instruments for the measurement of the altitude, the angle of path, and the actual speed is indicated in Chapter IV.

86. *Instruments for the conduct of fire.*—The altitude telemeter is indispensable for the conduct of fire. Based on the information contained in Chapter IV, it is easy to construct an improvised altitude telemeter with site corrector or a pointing wheel. The pointing wheel can not be used at night unless it can be lighted in such a way as not to interfere with the lighting up of the target.

When instruments are not available the future range is obtained from the tables called "Tables XV" (instructions of Dec. 24, 1915, see Chapter IV), which form part of the equipment of all stations.

APPLICATION OF FIRE DATA AT THE GUNS.

87. *Deflection.*—Making use of the tables provided to all stations, the deflection is roughly adjusted by means of a graduation on the shield.

88. *Laying for height and sight elevation.*—Guns which do not have the sight corrector do not have the sight scale. There are two cases:

(*a*) Guns which have a sight with double settings. The correction of site and the sight elevation are added algebraically. The sight elevation is taken from "Table XVI." (This and Table XV are not available. See similar tables forwarded with Capt. Levy's Study on Anti-Aircraft Firing.—Observer.) This table is written for sights graduated in mils. If the sight is graduated in meters, as for field fire, a new table must be made, changing the mils into fictitious ranges.

(*b*) Case in which it is not possible to make the setting on the collimator. The elevation is calculated. This elevation is a function of the fuse-setter range and the altitude and may be read on a table which it is easy to calculate and which should give the elevation in mils. (Table II.) Or it is possible to trace the trajectories on the altitude telemeter and to write on each one of them the corresponding elevations.

The elevation is given by means of a graduated sector assembled to the gun. It may be also considered as the sum of a fixed elevation given to the cradle and of a fictitious sight eleva-

tion which is characterized by the fictitious range on the sight drum to which it corresponds. These two angles are read at one time from a table which has been described (Table IV, dated Dec. 24, 1915). (Not available. See tables submitted with Capt. Levy's Study.—Observer.) Or the angles may be read from the trajectories traced on the altitude telemeter.

89. *The pointing wheel.*—The adaptation of the wheel of the altitude telemeter without corrector to the laying of improvised matériel is authorized as an experiment. (See p. 21.)

The scale support may be assembled to the hood of the collimator. If the laying-in direction is separated from the laying-in elevation, replace the point of sight prescribed in paragraph 27 by two cross hairs, one perpendicular to the plane of site for laying-in direction, the other horizontal for laying for elevation.

90. *Improvised matériel.*—Improvised matériel will not be used to increase the density of fire in zones covered by other batteries. Their unsatisfactory results will not justify the immobilization of a gun and its personnel.

Tables I, II, III, and IV.—While waiting for exact tables based on the work of the Gavre Commission, the Tables I, II, III, and IV of the instructions dated December 24, 1915, will be used.

Approved:

PARIS, August 15, 1916.

For the Under Secretary of State for Artillery and Munitions and by his order:

The General in charge of Field Artillery and Personnel,

DUMEZIL.

PROVISIONAL DRILL REGULATIONS.

January 28, 1917.

75 MM. ANTI-AIRCRAFT GUN, MOUNTED ON 1915 MODEL PLATFORM CARRIAGE.

These regulations are a sequel to the Provisional Instruction on Fire of August 15, 1916, and supplement it.

Taken together, these two Drill Regulations replace and cancel all preceding Drill Regulations.

TABLE OF CONTENTS.

INTRODUCTION.

Description and Mounting of the Platform Carriage. General Principles.

A. DESCRIPTION OF THE STATIONARY MOUNTING.

1. The 1915 model platform carriage is intended to permit the 1897 model 75 to be fired at high angles.

Its essential parts are—

A cemented pit.

A mount, revolving on a vertical axle and carrying the gun carriage.

Before being put in place the carriage should be stripped of wheels, wheel brakes, and shields, and provided with a counterpoise and a specially adjustable brake for vertical fire; further, the elevating drum should be replaced by a drum bearing a scale in mils (the 1897 model carriage can be replaced by a simplified carriage, 1916 model.

The *cemented pit* is 1 meter deep and 4 meters in diameter. A *circular iron band*, cramped into the outer curb of this bed, serves as a runway for the rollers of the mount.

A *socket*, set with cramping bolts in the center of the bed, receives the pivot of the support of the mount.

A pipe assures the drainage of the water which falls into the bed.

The mount is formed of two lateral *flasks* and two central *brackets* made of iron U beams assembled and riveted.

The vertical *uprights* of the flasks are braced and attached to the support of the pivot.

On top of these uprights are *trunnion bed plates* to receive the axle of the carriage. The axle is covered with *cap squares*, which are bolted to the trunnion bed plates.

The flasks and the central brackets are joined together by a *floor* on which the personnel of the piece stand.

The floor is left open between the two brackets to let the trail through.

Each flask has at its rear end, under the floor, a *brass roller*, which runs on the circular runway of the pit.

The roller of the right-hand beam is connected by a gimbal-mounted shaft and a bevel gearing to a controlling wheel, which permits of its being turned. The roller turning on the runway makes the mount rotate about the pivot.

The central brackets support a *winch* attached above the floor at the back.

The winch is worked with the aid of a wheel which, by the aid of bevel gearing and a gimbal-mounted shaft, moves a worm gear, which turns a cog wheel attached to the drum of the winch.

The trail of the gun is attached by the pintle hole to a steel cable rolled on the winch.

The cable being kept constantly taut by the preponderance of weight of the trail, the rotation of the winch makes it possible to vary the inclination of the gun. A *counterpoise* diminishes this preponderance and consequently the effort required to raise the trail.

For transportation the mount is dismounted into the following pieces: Right flask, with its upright and the central bracket; left flask, with its upright and the central bracket; pivot support, the two cross braces of the uprights, and the rear cross-brace; winch, and the machinery for controlling the winch.

In the equipment box are included the aiming apparatus, the devices for night lighting, the spare parts, the wrenches, and the objects necessary for setting up the platform carriage.

AIMING.

2. Aiming for height and aiming for direction are separated, and are performed by two cannoneers.

(*a*) The aim for direction is obtained by the rotation of the mount around the pivot of the bed. The movements of considerable amplitude are given by pushing the mount by hand. The movements necessary for aiming and for following the changing position of the target are given by acting on the apparatus controlling the driving roller.

The apparatus for aiming for direction is composed of a telescope mounted on a *goniograph*, or apparatus which automatically gives the correction for deflection allowance due to the change of position of the target as a function of the "elements of fire," which are: The altitude, the fuse-setter range, the speed of the target, and the angle of deflection. A special scale permits of "secondary corrections for deflection allowances," especially to allow for the wind.

There are two regular types of goniograph. For these two apparatus the telescope is given an elbow so that the axis of its eyepiece remains for all sites, except for the correction for deflection, parallel to the axis of the barrel on its trunnions. The direction pointer, seated on a seat connected with the right-hand flask of the platform, is placed so that he can easily

look through the telescope and act on the control of the driving roller. A deflection setter, placed near him, lays off the elements of fire on the goniograph. All the provisions of the present regulations apply equally to the two kinds of goniograph.

The 1897 model aiming apparatus mounted on aiming supports, which were those contemplated by the Drill Regulations of June 17, 1915, must now be considered only as provisional apparatus which will be sent back to the artillery parks as soon as they are replaced by goniographs.

In the same way the collimators which are in use on certain goniographs will be replaced as soon as possible by telescopes which make greater precision of aim possible. In the meantime it is evidently necessary to have the pointer and the setter change posts.

It follows that the provisions of the present regulations for the handling of pieces provided with apparatus other than the regular goniograph have the same provisional character.

(*b*) Aiming in height is done in principle by the wheel controlling the winch. This method of aiming is possible only for the matériel which has the 1915 model independent aiming apparatus. For the matériel which is equipped with an apparatus for aiming for height carried on the aiming support connected with the cradle, it is also possible to make the gun turn about the axis of the brake with the aid of the aiming wheel of the carriage. In that case, for small inclinations of the cradle, the trail of the carriage having been raised as far as it will go with the aid of the winch, this latter wheel will be used.

The regular aiming apparatus is the 1915 model independent aiming apparatus modified by the addition of the *sitogoniograph.* This apparatus is borne by a support attached to the left-hand flask of the platform. A parallel motion communicates to it the movements of the carriage on which the aiming cradle is held fast. The optical axis of the aiming telescope can always be adjusted with reference to the axis of the gun with the aid of three different movements—a movement in direction to permit the gunner to find the target in the field of his telescope whenever there is a deflection allowance, a movement in height to permit giving the correction for site, and another for giving the elevation. The angle of the elevation is given automatically with the aid of an elevation table graduated in fuse-setter ranges. The correction for site is

given automatically by the sitogoniograph, on which it is necessary only to lay off the elements of fire. The secondary corrections are corrected with the independent elevation handwheel, the 1897 model elevation drum being replaced by a drum graduated in mils.

The elevation pointer is posted on the platform, facing the direction of fire, with the wheel controlling the winch at his right.

The operation of the elevation and of the sitogonigraph is entrusted to two cannoneers placed on seats attached to the left flask of the platform.

With the simplified carriages, which do not have any independent elevation handwheel, the regular apparaus for aiming for height is the 1915 model independent aiming apparatus, unmodified. The correction for site, which should be laid off on it, can be determined by a *hand sitogoniograph.*

The double adjustable aiming apparatus, the drum for correction for site, and the plummet elevation table will generally be replaced by one of the above apparatus. The rest of these present regulations does not consider the case of pieces equipped with these apparatus. Post commandants who are still provided with them will instruct their elevation pointers, sight setters, and elevation cannoneers according to the principles of these present regulations, making allowances for the differences which result from the difference of the apparatus. The independent aiming apparatus without corrector will be kept in the posts where it exists.

B. DESCRIPTION OF THE SEMISTATIONARY ARRANGEMENT INTENDED FOR THE ARMIES.

3. The platform carriage intended for the armies has a mount identical with that of the stationary installations of the forts, but its lower structure is simplified.

The pit is made by an excavation in the form of a truncated cone 1.2 meters deep, 1.8 meters bottom diameter, and 4 meters top diameter.

The *circular runway* is made of iron and bolted on 12 short planks.

For transportation it is taken apart into four elements.

The *socket* is bolted to a *bed* formed of two tiers of scantlings bolted together for the purpose of distributing the pressure of

the pivot on the ground. The socket is centered in the runway by eight iron rods bolted to the runway and to the bed.

A *sheer* is used for putting the gun in place on the platform carriage.

The platform carriage, independent of the gun and of the various apparatus necessary for conducting fire, can be transported on two trucks, one of which should have a flat floor without rails.

On this truck are placed—

(*a*) The two flasks of the mount, laid flat, with the upright perpendicular to the axle of the vehicle;
(*b*) The accessories case, containing the crosspieces, the wrenches, hammers, assembling spikes, etc.;
(*c*) The winch;
(*d*) The equipment box.

On the second truck are placed—

(*a*) The circular runway, taken apart into four elements;
(*b*) The socket support bed and its stay rods;
(*c*) The sheers;
(*d*) The operating levers, ropes, short planks.

The trucks are not listed in the matériel allowance of the units. In case of need, the trucks are furnished to the units by the army. The same is true of the limbers and the horses necessary for the transportation of the gun, apparatus, and various equipment.

ERECTION OF THE PLATFORM CARRIAGE.

PUTTING THE RUNWAY IN PLACE.

4. The description of this operation will refer only to the semistationary matériel. It includes the following operations:

(*a*) *Set up the runway.*—Level and ram the earth for the emplacement of the runway.

Take the runway from the truck, place its four elements together and assemble them with bolts, steel clamps, and wooden wedges.

Test the horizontality of the runway by the 4-meter rule and the mason's level; make it level, if necessary, by tamping earth under the low parts and pounding with the beetle on the high parts.

(*b*) *Dig the excavation.*—Dig up the ground inside the runway and throw the earth outside, ramming it against the run-

way. Having thus dug in the middle a hole 2 meters in diameter and about 1.2 meters deep, make its sides slope from this bottom to the edge of the runway. Thoroughly ram the bottom of the excavation to make it level, and make sure, with the aid of the 4-meter rule and the gauge laid across the runway, that the profile of the excavation has the proper dimensions.

(*c*) *Put the bed in place.*—Lower the bed to the bottom of the excavation, letting it slide on two planks laid flat against the sloping sides. Then, with levers, move the pivot to the center of the hole and orient the bed so that the sheers trunnion supports are at a side of the pit easily accessible to the gun and that the stay-rod fastenings are opposite the corresponding fastenings on the runway. Bolt the rods on the bed and on the runway. Then throw earth between the joists and the bed and ram it down well. Fill the excavation in this manner up to the level of the top of the joists.

ERECTION OF THE MOUNT.

5. First. Take off the nut of the pivot, set the pivot support on the pivot, replace the nut.

Second. Put the two flasks on the platform and let them down into the excavation, the roller on the runway, the foot of the upright in the bottom of the pit on a short plank about 15 centimeters thick and set so as to block the pivot.

Third. Take up one of the flasks and raise its foot above the pivot support. Place the feet of the upright and of the bracket against their supports on the pivot support. Put in place the assembling bolts, using, if necessary, a spike and hammer to make the bolt holes in the two pieces coincide. Do not tighten the nuts fully. During this work, the back of the central bracket should be supported and the roller should be held stationary on the runway by wooden wedges.

Fourth. Do the same with the other flask.

Fifth. Connect the two flasks, first bolting the rear floor crosspiece without tightening the nuts and then the middle crosspiece of the uprights.

Sixth. Tighten the screws, beginning with those of the middle crosspiece of the uprights.

Seventh. Bolt the winch support on the two flasks and tighten the bolts.

Eighth. Put in place the controlling gear of the winch, assembling the gimbal bearing at the end of the shaft of the worm gear.

Ninth. Push the back of the platform by hand and make it execute a complete turn to make sure that it rotates freely.

ERECTION OF THE GUN.

6. *For fire against aerial objectives only brakes specially adjusted for vertical fire must be used.*—First dismount the shields and the wheel brake, then, turning the handwheel for aiming for direction, put the axle cover at the middle of the axle.

Turn the platform mount so as to set the pivot support parallel to the bearings of the trunnions at foot of sheers. Make it stationary in this position by blocking the rollers.

Place the sheers on the front of the platform carriage, the trunnions at its foot engaged in the bearings and held by the hooks, its uprights resting on the runway.

Draw the piece, trail foremost, on the axle of the platform and run the wheels up on two short planks resting on scantlings on the runway, so as to make an inclined plane raised about 30 or 40 centimeters above the runway. Let the trail pass between the uprights and rest on the middle crosspiece, then hook the cable of the winch to the pintle eye, using a rope instead of the assembling link.

Roll the gun back until the necks of the axle sleeves engage in the forks of the sheers, so as to exert a slight tension on the cable.

Attach a rope at either side of the axle. Pass these ropes over a crowbar which rests on the trunnion beds.

Tie a holding rope about the gun.

To raise the gun the elevation pointer places himself at the controlling wheel of the winch; two cannoneers place themselves at each wheel of the gun and two at the muzzle; the other cannoneers, in two equal groups, place themselves on the floor and at the back of the platform, and each group seizes one of the ropes attached to the axle.

At the order of the chief of section all the men make an effort to raise the piece. As soon as the wheels have been raised a few centimeters the cannoneers who are stationed there take them off and lay them on the ground; they put back in place on the axle the cup-shaped washers and the linchpins and rings.

Then all make an effort to continue to raise the piece, letting the sheers down vertically against the uprights.

Toward the end of the movement the crowbar is taken away, the cap squares are raised; the cannoneers at the wheels make an effort to let the sheers down gently against the uprights.

The chief of section, with a handspike, steers the trail between the uprights so as to permit the passage of the handwheels controlling the carriage movements. He steers the trail between the brackets below the winch.

The sheers being raised vertically, the chief of section assures himself that the axle covers of the carriage are properly placed between the trunnion beds on the uprights. If this is not the case, he turns the handwheel for laying-in direction so as to move the piece on its axle in the desired direction.

Then the axle is gently lowered into the trunnion beds, working on the sheers. The cap squares are lowered and bolted.

The sheers is cleared by making its foot slide on the carriage bed. It is then taken off and laid away from the platform.

NOTE.—To take the sheers off, two men stand at the foot and two at the head; raise the foot out of the pit and let it rest on the runway; clear the head.

A plank is set up to make a bridge between the runway and the middle crosspiece of the uprights. The counterweight is put on this plank under the barrel of the gun.

Through the hole in the center of the counterweight the steel cable of the counterpoise is passed. A cable attached to the counterweight by a running knot and also a crowbar are likewise passed through this hole. The rope makes a turn and a half about the barrel of the gun and its end is seized by a man placed on the runway. The crowbar is seized by two men standing in the bottom.

At an order of the chief of section a man takes hold of the counterweight; aided by the men who hold the crowbar, he raises the counterweight held by the rope which a cannoneer slips around the barrel until both ends of the metal cable can be passed over the axle cover, a complete turn from below, and then assembles the ends of the cable to the counterweight by means of bolts and nuts.

The buttress is set in place, catching its foot in the angle formed by the upper plate of the trail and the rear crosspiece, the channel for the wheel brake block fitting into the recess made in the buttress. Its other end is then engaged in the

recess of the counterweight, and finally the foot of the buttress is fixed to the trail by means of the counterpoise washer and of the nut coming from the wheel brake.

The ropes and crowbar are taken away and the plank is removed after having lubricated the cable. The rope tied in the pintle eye is removed and the assembling link is put back in place.

The upper cross piece is bolted. The ropes tied to the axle and the barrel and the wedges which block the rollers are removed. The apparatus for laying for height and for direction is mounted.

TAKING DOWN THE GUN FROM THE PLATFORM CARRIAGE.

7. Take off the upper cross piece of the uprights.

Put a rope in place of the link for assembling the cable of the winch and the pintle eye.

Place a plank to form a bridge between the runway and the middle cross piece of the upright.

Take off the nut and the washer of the equipoise. Pass through the central hole of the counterweight a rope arranged and held by a cannoneer as described for the mounting and the bar. Take off the nuts holding the ends of the metal cable.

Take away the buttress.

Let the counterweight down gently, two men standing in the bottom hold it by the bar and one man placed on the plank plays out the rope. It then rests on the plank. Take it out and take away the plank.

Operate the winch to raise the trail into contact with the winch.

Turn the platform carriage to bring the pivot-support cross piece parallel to the bearing of the journals of the foot of the sheers.

Place the sheers on the bed[1] as when mounted in it, and engage the forks in the necks of the axle sleeves. Tie a rope each side of the carriage on the axle.

Raise the cap squares, operate the sheers to raise the gun and clear the axle of the trunnion beds.

Push the carriage forward until it is in equilibrium; make sure that the ropes are well passed over the uprights of the inte-

[1] To place the sheers, first engage the head with the uprights on each side, then let the foot down into the pit, lower the hooks on the journals of the foot.

rior side and let the piece down gently, the ropes being held by the cannoneers mounted on the platform as in mounting.

The elevation pointer turns the winch so as to permit this movement; he must turn the handwheel quickly enough, and the other cannoneers must hold the ropes sufficiently so that it is not the winch which controls the movement.

Put the wheels in place on the axle, detach the cable from the trail and hook the piece to its limber.

DISMOUNTING THE PLATFORM CARRIAGE.

8. Dismount the winch control; for this purpose, take out the pin and the axis of the gimbal bearing and the worm gear. Then put these pieces back in place on the bearing, after having separated the driving shaft. Attach this shaft to the frame with a string.

Dismount the winch and the cross pieces of the flasks, being careful to fasten the assembling bolts on each of the dismounted pieces, screwing the nuts by hand.

Place short planks beside the pivot as for the mounting.

Unbolt the pivot support.

Raise each of the flasks to clear it from the pivot support, make it balance on the flat, and place it on the transport truck.

Unbolt the stay rods, take them off the bed.

Dismount the runway, knocking out the wedges with the hammer.

Take away the bed; for this purpose clear away the earth heaped around the transoms, raise the bed by levers, then pull it out of the excavation by ropes, sliding it along two planks.

D. ORGANIZATION OF THE SECTION AND PRINCIPLES OF INSTRUCTION.

9. *Composition of the platoon.*—The platoon comprises one or two guns, generally two. The table below gives the composition of the personnel in either case. The platoon is under command of a lieutenant or second lieutenant. In platoons of two guns, this officer has an assistant, having the grade of lieutenant or second lieutenant or (exceptionally) of sergeant major.

The personnel of the platoon is divided into—

- One or two guns, each commanded by a sergeant.
- One commander's detachment (second or third) commanded by a sergeant.
- One searchlight, commanded by a corporal.

Table of the personnel necessary for fire.

	Post of 1 gun, or semistationary post.				Post of 2 guns, or semistationary platoon.			
	Officer.	N. C. O.	Corporals.	Cannoneers.	Officer.	N. C. O.	Corporals.	Cannoneers.
Officers	1				[1] 2			
First gun [2]		1		11		1		11
Second gun [2]						1		11
Commander's detachment [3]		1	4	13		1	4	13
Total personnel necessary for fire [4]	1	2	4	24	2	3	4	35

[1] One officer may be replaced by a sergeant major.
[2] See detail in Chapter I.
[3] See detail in Chapter II.
[4] The unit also includes—
Semistationary post: 1 N. C. O., 1 corporal, 5 cannoneers; semistationary platoon: 1 N. C. O., 1 corporal, 8 cannoneers, divided among the pieces; and the searchlight, served by 1 corporal and 4 men.

DIVISIONS OF THE REGULATIONS.

10. The object of the present regulations is to put into practice the principles set forth in the Provisional Instruction of August 15, 1916, on the fire of the 75 mm. gun against aerial objectives.

It comprises an introduction and three chapters:

Chapter I. The Gun.
Chapter II. Commander's detachment.
Chapter III. School of the platoon.

GENERAL PRINCIPLES.

11. "*Act as a model for your men.*" In the instruction of the men the following principles will be observed:

1. *Use the largest possible number of instructors.*—In this way the men are in small groups and execute often what they are being taught. To understand is not enough; the man must reach the point of reflex execution of the functions committed to his charge.

2. *For giving instruction in a movement.*—(*a*) If the movement is complicated, divide it into parts, each part being made the object of a special instruction. (*b*) At first teach the man the nomenclature which will be used in the course of the instruction. This introduction in nomenclature must be given in such a way as to give him a first idea of the operation of the appa-

ratus. (*c*) *Show* the man the movement, " act as model for him," speak to his eyes, and avoiding all useless talk. Use the voice only to call his attention to the important precautions to be taken. This requires that the noncommissioned officer be an excellent operator, and that the man always be placed so that he can see clearly. (*d*) Verify the man's understanding by making him repeat the nomenclature and execute the movement, avoiding all shams. Ask at first no more of him than accurate work. Speed will come of itself in consequence of the *automatic action* obtained by *repetition.*

3. To keep the attention keen *vary the program* in the course of each drill and, if possible, vary the nature of the matter taught, avoiding all exaggeration.

4. Devote the greatest care to recognizing the aptitudes of each man, so as to be able to assign each cannoneer definitely to the post which suits him best.

Aerial targets, being particularly rapid and fugitive, require extreme rapidity of fire. *It is therefore the imperious duty of each commander of a unit to maintain his personnel in the highest state of training.*

The use of the time of each unit should therefore include two short drills daily on friendly or simulated airplanes, and these drills should be omitted only in case of real fire.

The chief of platoon will increase his qualifications as a marksmay by making his own criticism after each fire.

He will also criticize his subordinates on what he has seen himself, taking into consideration all that occurred.

CHAPTER I.

THE GUN.

" Let each know but one thing, his orders."

A. SCHOOL OF THE CANNONEER.

DUTIES OF THE CANNONEERS.

12. The service of the piece is executed, under the direction of an N. C. O., chief of section, by 11 cannoneers whose principal duties during fire are the following:

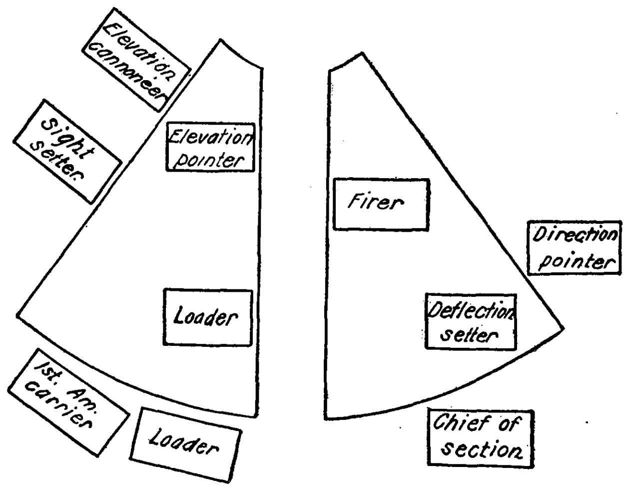
3 ammunition carriers___Keep the fuse setter supplied with cartridges.

1 fuse setter____________Lays off the range on the fuse setter and sets the fuse of the cartridge.

1 loader——————Puts the cartridge in the bore.
1 firer——————Opens and closes the breech and fires the piece.
1 elevation connoneer——Gives and maintains the range.
1 direction pointer——Lays for direction.
1 deflection setter——Lays off the elements of fire on the apparatus for laying for deflection.
1 elevation pointer——Lays for elevation.
1 sight setter——Lays off the elements of fire on the apparatus for laying for altitude.

POSTS OF THE CANNONEERS DURING FIRE.

13. Indicated by the sketch below.



The second and third ammunition carriers move about the piece.

DUTIES OF THE AMMUNITION CARRIERS.

14. *Post 3.*—The second and third carriers circulate between the platform and the ammunition chests. The first carrier stands on the ground, in rear and to the right or in rear and to the left of the fuse setter.

Duties.—(*a*) Take the cartridges from the chests and place them in the stands placed near the fuse setter (second and third

carriers); (*b*) keep the fuse setter supplied with cartridges (first carrier).

(*a*) *Take the cartridges from the chests and place them in the stands placed near the fuse setter* (second and third carriers). (NOTE.—These stands should be filled when fire commences.) Go to the chests containing the cartridges of the type indicated by the fire commander. (NOTE.—Whatever their type, the cartridges are generally divided in three chests set about the piece and at the three vertices of an equilateral triangle.) Take two cartridges, return to the platform and set them on the stand within reach of the first carrier. Try to maintain practically constant the number of cartridges in the stands. When the available personnel permits, an additional man can be added to the number of carriers, especially if movement about the platform is easy. In case of need, the chief of section will himself fill the post of extra carrier.

(*b*) *Keep the fuse setter supplied with cartridges* (first carrier).—Take the cartridges one by one from the stands which are placed near the fuse setter on the floor of the platform; set the cartridge over one of the ogive openings of the fuse setter, vertically, the fuse toward the bottom, holding it with one hand at the ogive and the other at the base; let it down without shock on the bottom of the opening, watching the ogive; with the hand which remains on the base turn it slowly in the clockwise direction until its tenon falls into its mortise.

At each cessation of fire and on the order of the chief of section, the carriers will take out the cartridge cases which have fallen into the basin.

FUNCTIONS OF THE FUSE SETTER.

15. *Post.*—Standing on the ground, facing the fuse setter, which is on the floor of the platform.

Follow the platform when it is moved. (Posts which fire shells requiring the use of two fuse setters, place them one beside the other on the back part of the floor of the platform. Post commanders are authorized to modify the placing of the fuse setter and to place him on a projection fixed to the platform.)

The fuse setter is generally equipped with a telephone apparatus with headpiece.

Duties.—(*a*) Lay off corrector. (*b*) Lay off range. (*c*) Set the fuse of the cartridge. (*d*) Hand the cartridge to the loader.

(*a*) *Lay off the corrector.*—The corrector to be laid off is, when not otherwise ordered (particularly for trial fire and in case of modification following trial fire)—

For fire against an airplane—
With 30/55 fuse; corrector 14.
With 22/31 fuse; corrector 21.
With 24/31 fuse; corrector 17.
For fire against a dirigible—
With 30/55 fuse; corrector 10 (shrapnel or tracer shells).
With 22/31 fuse; corrector 17.

To lay off the corrector:

(1) Fuse setter 30/55: Push the spring button of the corrector and bring the reference line opposite the desired division.

(2) Fuse setter 22/31: Release the clamp screw of the corrector and move the latter with its two indices until the reference line is opposite the desired division; then, holding the corrector with one hand, tighten the clamp screw with the other.

(*b*) *Lay off the range.*—The range is given to the fuse setter in hectometers by the telephone operator. (It is absolutely necessary that the range set off by the elevation cannoneer be the same as that used for setting the fuse of the cartridge placed in the gun. To avoid any error the ranges are reported in hectometers by the telemeter operator; when the fuse setter hands the cartridge to the loader, he reports the range in meters. Repeated by the loader, this range accompanies the cartridge and is heard by the elevation canoneer.)

The range is transmitted by telephone, or, failing that, by speaking tube, or by transmitter.

At the order, "A certain range" (for example, 59). With the right hand seize the hand piece of the handwheel, press on this to ungear it, and turn it in the proper direction until the range indicated is opposite the reference line. Release the handwheel and set the fuse of the cartridge. (Avoid errors of the telephone operator, which may be committed with the 30/55 fuse setter if the reading is taken on the graduation for short ranges while the index is adjusted for long ranges. It is no longer necessary, as in the fire at terrestrial targets, to terminate the movement in the sense of augmentation. This course would delay the fire and would only give an illusory increase in precision.)

At the order: "With tracer shells." Set the special index and read the ranges on the red graduation.

Change of cartridges.—Unless otherwise ordered, 22/31 shells are fired up to 6,900, and 30/55 beyond 6,900.

On opening fire, and at the time the first elevation is ordered, the fuse setter calls out in a loud voice the fuse setting which is to be used at the command "22/31" or "30/55"; he afterwards calls in the same way every change in the fuse setter. (This provision only applies until the 30/55 shells can replace all others. An extension-tube time fuse, which will permit the fire of 22/31 shell beyond 6,900, has just been put in course of manufacture.)

(*c*) *Setting the fuse of the cartridge.*—Grasp the lever with the right hand, lower it energetically as far as it will go, so as to pierce a hole through the fuse, raise it completely and to the vertical, so as to withdraw the bit from the fuse, release it, and quickly hand the cartridge to the loader.

Always work the fuse setter with the right hand and as far as it will go.

(*d*) *Hand the cartridge to the loader.*—Seize the cartridge with the left hand above the band, raise it to withdraw it from the ogive opening, place the inverted right hand under the ogive and pass the cartridge to the loader with the ogive forward, calling in meters the range for which the fuse is set (for example, 5,900).

DUTIES OF THE LOADER.

16. *Post.*—Standing to the left of the gun, at about 1 meter behind and to the left of the breech, facing the breech.

Duties.—*Take the cartridge from the hands of the fuse setter and commence to insert it in the chamber.* Lunge to the right, take the cartridge passed by the fuse setter, the right hand at the base, the left hand back of the ogive, face toward the firer, carefully introduce the ogive into the chamber; letting go the projectile with the left hand. Slide the cartridge in by pushing it with the right hand, then let the firer complete the movement. As soon as the preceding shot has been discharged, repeat to the elevation cannoneer the range called by the fuse setter. Also repeat the calls 30/55, 22/31, explosive shells.

DUTIES OF THE FIRER.

17. *Post.*—Standing at the right of the gun, beside the breech and facing the handle.

Duties.—(*a*) Handle the safety lock. (*b*) Open and close the breech. (*c*) Finish the loading. (*d*) Fire the gun. (*e*) Handle the rammer. (*f*) Give the secondary corrections for site (except in case of guns equipped with independent sitogoniographs).

(*a*) *Handle the safety lock.*—The breech being closed and the safety lock in march position, to put it in the fire position seize the lug of the stop bolt with the left hand, draw it toward the rear, give it a movement of rotation toward the right until the movement stops, and let it go.

The safety lock being in the fire position, to put it in the march position, repeat the same movements, turning the safety lock to the left.

(*b*) *Open and close the breech.*—To open and close the breech seize its handle with one or both hands, backs down, and turn it until the movement stops. The end of the opening movement which produces the ejection of the cartridge case should be made energetically.

When the cartridge is introduced into the bore, the rim of its case comes in contact with the extractor and starts the closing movement of the breech. The firer must be very careful not to check this movement, but to continue it, and screw the breech until the movement completely stops. Hold the breech at the end of its movement in order to avoid its bounding back in case the catch fails to work. Then drop the hands to the side.

(*c*) *Finish the loading.*—Finish the loading which the loader started by pushing the cartridge all the way in with the left hand, which should be protected by a special glove. Close the breech with the right hand.

(*d*) *Fire the gun.*—The piece being loaded, at the word "ready" given by the deflection pointer, and after heeding any direction given by the elevation pointer (see No. 21), fire the gun. To do this, lean over and seize the fire handle with the right hand, pull it back and slightly down until the movement stops, and release it sharply.

In case of misfire, repeat the fire operation, stop after two more unsuccessful efforts, wait a few seconds and open the breech, then follow the instructions given in Article 27.

(*e*) *Handle the rammer.*—The rammer and sponge are mounted and handled by the firer only. They are not put back in place except in case of change of position.

To extract a cartridge or a cartridge case, put the rammer in the muzzle of gun and knock with the head of the rammer on the fuse of the projectile or on the base of the case. If it is a cartridge which is being extracted, the loader, standing at the breech, receives it in both hands.

(*f*) *Give the secondary corrections for site* (except for the guns which are served with a *hand* sitogoniograph, on which the secondary corrections are registered).

At the command "drum so much" from the cannoneer who gauges the wind have the division named marked on the independent range drum. This command is transmitted either by the deflection setter[1] or by the operator of the speaking tube.

DUTIES OF THE ELEVATION CANNONEER.

18. *Post.*—Facing the quadrant on a seat connected with the outside of the left-hand flask of the platform.

Duties—Lay off and maintain the range.—When the range is called by the fuse setter (and repeated by the loader), take hold of the lower edge of the range disk, turn it so as to bring the point of the index on the curve corresponding to the range ordered and hold it there in spite of the movements of the index which are due to the continuity of the laying of the gun. Each range must be maintained until the discharge of the round with the fuse set for that range, even if the fuse setter has already called the range of the next round.

For designation of targets, set the quadrant at zero.

Changes of range below 500 are made rapidly. Changes of range over 500 are given progressively, so that the target will not get out of the field of the telescope.

On the mixed disk, the distance curves of the 22/31 are in black, the curves of the 30/55 in red. The kind of fuse is called at each change by the fuse setter and repeated by the loader.

DUTIES OF THE DIRECTION POINTER.

19. *Post.*—On a seat connected with the outside of the right-hand flask, the right eye at the eyepiece, both hands on the wheel for laying for deflection.

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[1] In case the wind table is placed on the gun (see note to No. 20), the layer for deflection difference reads the correction directly on the wind table.

Duties—Pointing for direction.—Turn the handwheel in the proper direction to bring and keep the target on the vertical wire of the reticule.

After each correction for deflection re-lay as speedily as possible. Also keep the target from getting out of the field of the telescope by giving the laying apparatus slight movements in height. These movements are given with only one hand by the layer who works rapidly enough not to let go the wheel with this hand for more than a very short instant. They can also be given by the deflection setter when called by the direction pointer.

When the breech is closed, the laying having been verified, call " ready " and keep the gun very exactly laid until the discharge of the round.

Lay the gun roughly for deflection.—The laying is done in the rough, either by the deflection setter or by the direction pointer, who leans to the left so as to look through the collimator.

DUTIES OF THE DEFLECTION SETTER.

1. GUNS EQUIPPED WITH A GONIOGRAPH.

20. *Post.*—In rear of the deflection sight, seated or standing and facing the apparatus.

The deflection setter is generally equipped with a telephone apparatus with headpiece, which puts him in communication with the telephone central of the commander's detachment (No. 39). Orders come to him by telephone, except the range, which is given by the loader.

In case telephone apparatus is not available, orders are given verbally by the chief of section, who receives them by a telephone with headpiece (thus saving a telephone per gun), or by speaking tube.

Duties.—(*a*) Give the correction for deflection. (*b*) Give the secondary corrections for deflection. (*c*) Transmit the commands to the firer (except with guns equipped with the hand sitogoniograph).

(*a*) *Give the correction for deflection.*—At the command for *speed*, for example, " Speed 35," turn the two cylinders on each other so as to bring the graduation of speed commanded opposite the reference line corresponding to the projectiles being fired (22/31, 30/55, explosive). In case of doubt, ask the fuse setter for the fuse.

At the command for *altitude* (for example, "Altitude 3,500 "), place the index of altitude at the altitude commanded.

In the course of fire, the altitude is modified only in case of great variations (more than 500 meters).

At the command for *range* (for example, "6,200"), turn the cylinders so as to bring the curve corresponding to the range and the kind of shell commanded opposite the index of altitude.

In the course of fire, the distance must be given in round figures in multiples of 1,000 meters (given true to the nearest 500 meters). It is therefore not necessary to modify it at every round.

At the command for *orientation* (for example, "Is coming +45"), move the principal alidade, taking hold of its clamp screw and bringing the index of deflection opposite the curve of orientation commanded.

In the course of fire, modify each element according to the orders received, and after each modification affecting an element other than the orientation give it once more the last orientation commanded.

For designation of targets, give the orientation zero.

(*b*) *Give the secondary corrections for deflection.*[1]—At the command "Deflection plus so much," or "Deflection minus so much," lay off the deflection commanded on the secondary corrector of the goniograph by turning its adjusting screw. (For apparatus not equipped with adjusting screws, slightly block the principal alidade, give the correction by loosening the secondary alidade, if necessary, and then free the principal alidade.)

(*c*) *Transmit the commands to the firer* (except for the guns equipped with independent sitogoniographs).

Repeat to the firer the orders "Drum so much" received by telephone (or read them on the wind disk).

2. GUNS EQUIPPED WITH THE 1897 MODEL LAYING APPARATUS.

Based on the reports of speed, altitude, distance, orientation, received as described above, read the deflection on an appropriate table and give it to the apparatus.

[1] Posts can construct makeshift wind disks, similar to the one described in Appendix III, and which turns automatically at the same time as the gun. The corrections for adjustment are registered on the movable rule of the wind disk. The deflection setter from time to time looks at the disk and reads the total secondary correction (wind and corrections of adjustment) and lays it off on the secondary corrector of the goniograph.

At the command "Increase or diminish by so much," change the deflection by the quantity indicated, and keep the correction to modify consequently the deflection read on the table.

If several corrections are commanded successively, it is the total of these corrections which is to be kept.

DUTIES OF THE ELEVATION POINTER.

21. *Post.*—On the floor of the platform, facing in the direction of fire, with the handwheel for operating the winch at his right.

Duties—Lay for elevation.—With the right hand, turn the wheel operating the winch so as to keep the targets on the horizontal line of the reticule of the telescope.

Give the desired direction to the telescope either with the nose or with the left hand.

When the breech is closed, keep the laying very exact until the discharge of the round. If by chance the gun is not laid, warn the firer by the signal "top," followed as soon as possible with the signal "ready."

DUTIES OF THE SITE SETTER.

22. The site setter is usually equipped with a telephone apparatus with headpiece, putting him in communication with the commander's detachment. He receives the commands by telephone, except the range, which is repeated near him by the loader, and which he can read on the range-finding attachment. If a sufficient number of telephone apparatus are not available, the commands are made by voice by the chief of section (see No. 20).

Post.—On an outside floor connected with the left-hand flask of the platform, at the right of the range cannoneer and facing the laying apparatus.

Duties.—Laying off data.

1. Gun Equipped with the Independent Apparatus with Sitogoniograph.

At the command for *speed* (for example, "Speed 35"), move the speed slide so as to bring its reference line opposite the division named (one of the reference lines is for shells with 30/55 fuses and for the explosives, the other for the 22/31 fuses; in case of doubt, ask "Fuse?" of the fuse setter).

At the command for *altitude* (for example, "Altitude 3,500"), move the index of altitudes so that its point comes opposite the line corresponding to the altitude commanded. In the course of fire the altitude should be given to within 200 meters.

At the command for *range* (for example, "6,200"), with the right hand move the rod which carries the speed slide and the index of altitudes so as to bring the proper point of this index on the curve corresponding to the range commanded and to the kind of shell used.

In the course of fire the range should be given in round numbers, in kilometers, up to 6,000, and in multiples of 2,000 beyond that. It therefore need not be changed at each round.

At the command for *orientation* (for example, "Is coming +45"), with the left hand move the orientations disk so as to bring the index borne by the speed slide to the curve corresponding to the orientation commanded.

In the course of fire, change each element as orders are received, and after each change affecting an element other than the orientation give again the orientation commanded.

For the designation of targets, set the correction for site at zero (graduation on the edge of the drum).

2. Gun Not Equipped with the Regulation Sitogoniograph.

The site setter reads the correction on a "hand" sitogoniograph, the operation of which is similar to that of the goniograph, and lays it off by moving the drum of the corrections for site. In this case it is he and not the firer who notes the secondary corrections for site, which are then transmitted in the form "ruler+20," for example.

Failing a hand sitogoniograph, read the correction on a table.

Note.—Platoons comprising two guns are authorized to calculate the total correction for deflection and the total correction for site at the commander's post, and to transmit them by telephone or speaking tubes to the layers in the form "Deflection, plus or minus so much," or "Disk so much, drum so much," and "Site, plus or minus so much." This process is particularly recommended for the guns which have neither goniograph or sitogoniograph. In that case it is further recommended, contrary to the provisions of No. 34, to lay off on the altitude telemeter the same correction for site as is laid off on the gun. To keep account of the variation of range during the time lost in sighting and laying, it is then necessary to conform to what has been said in the Instruction on Fire (No. 28) for the altitude telemeter of the auto-mounted light gun.

B. School of the Piece.

VERIFICATION OF THE LINES OF SIGHT.

23. This verification is very important. It should be frequently made by an officer.

(*a*) *Apparatus for laying for deflection.*—The adjustment comprises three operations:

(1) *Verify the lines of sight for a point of small site.*—Loosen the nuts which hold the supports of the laying apparatus. Direct the gun on a point situated at more than 1,000 meters distance, using the natural line of sight. Lay off on the laying apparatus the division disk *O*, drum 100, for the 1897 model apparatus or zero for the goniograph. Turn the support of the laying apparatus so as to bring the vertical fiducial edge (or the vertical cross-hair of the telescope) on the point chosen. Tighten the side binding nuts. Verify that this tightening has not turned the apparatus.

(2) *Verify the horizontality of the axis of the apparatus on its journals.*—Failing of star of large site (when it is sufficient that the lines of site remain adjusted for laying on the star), attach solidly to the muzzle of the gun a rod as near as may be parallel to the axle. Draw a pencil line on this rod at the place where it is cut by the direction of sight of the laying apparatus, the apparatus being kept at the same division as before. Make sure that when the inclination of the gun is changed the direction of sight of the laying apparatus remains directed on this line. If this condition is not obtained, try to obtain it by a suitable shifting of the piece bolted to the flask of the platform which carries the support of the laying apparatus. This shift can be obtained by inserting pieces of sheet iron between this piece and the upright of the platform.

(3) *Recommence the first operation*, with the exception that for the apparatus equipped with goniographs it is necessary to lay off the *division minus 5 and not the division zero.* Tighten the assembling nut of the apparatus. Make sure that this tightening has not turned the apparatus, and, if necessary, recommence the operation, taking care to fully block the side nuts before turning the assembling nut.

(*b*) *Apparatus for laying for altitude.*—The verification of the lines of sight comprises five successive operations:

(1) *Verify the verticality of the axis of the socket of the fixed support.*—Place a level on the upper edge of the bracket,

first parallel and then perpendicular to the joist, and make sure that in these two positions the bubble is between its lines. If it is not, loosen the bolts of the fixed support. According to the direction in which the verticality is not assured make the brackets play toward the front or toward the rear, taking advantage of the play between the assembling bolts and their holes, or insert between the fixed support and the joist pieces of sheet iron of the requisite thickness. Once more verify their verticality. This operation does not need to be made with very great precision.

(2) *Make sure of the parallelism of the axle with the axis on the journals of the apparatus.*—Lay for direction on a distant point (more than 500 meters) with the natural line of sight of the gun. Place the adjusting collimator on the angle iron of the rear arm, well supported against the flange, and turn the whole apparatus about the vertical axis until the vertical fiducial edge of this collimator passes through the chosen point. Make the apparatus immovable by first lightly tightening the side nuts and then tightening the bottom nuts. Verify that this tightening has not turned the apparatus and recommence, if necessary.

(3) *The quadrant and the drum of corrections for site being at zero, verify if there is an angle of 45 degrees between the direction of sight of the laying apparatus and the plane of the angle iron of the rear arm.*—For this purpose place the square of 45 degrees on the angle iron of the rear arm, and on this square place the adjusting collimator. The quadrant and the site-correction drum being at zero and the apparatus held perfectly motionless, make sure that the line of sight of the collimator and that of the laying apparatus are directed on the same point. (This operation should be made before the coupling up of the front and rear arms). If this is not the case, turn the two adjusting screws which hold in place the finger of the telescope support until the parallelism of the two lines of sight is effected.

(4) *Verify the parallel motion.*—Couple up the front and rear arms. Place the level on the angle iron of the front arm and turn the wheel operating the winch so as to bring the bubble between its lines. Then place the level on the angle iron of the rear arm and bring the bubble between its lines by turning the adjusting nut of the connecting rod; then hold it fast by the side binding nuts. Verify that this binding has not affected the parrallelism of the two arms.

(5) *Verification properly so called of the lines of sight.*— Lay off the division 100 on the quadrant in mils, the final movement being one of elevating the breech. Place the level on the angle iron of the rear arm. Bring the bubble between its lines by turning the wheel which operates the winch. Let the final movement be in a very definite direction, for example, lowering the muzzle. Set the 45-degree square, bearing its level on the seat of the gunner's quadrant. Turn the wheel controlling the cradle and bring the bubble between its lines; let the final movement be in the direction which elevates the breech. Read on the wheel the number obtained (one turn of the wheel is equal to 16 mils). Recommence the same operations, but let the movement given the muzzle to make the angle irons horizontal end in the contrary direction. Note the new number obtained. Place the wheel in the middle position resulting from these two measurements, finishing in the same direction as before (elevating the breech). Make it immovable by means of its bolt, and fasten it to the carriage.

The difference of the two measurements should not exceed 10 mils. When it does, try to obviate the play which there may be between the carriage and its axle by making them immovable in regard to each other, using makeshift means.

NOTE.

(*a*) If there is an elevated laying point available (a star), operations 3 and 5 may be replaced by the following: The quadrant and the site-correction drum being at zero and the quadrant at 100 mils, lay for altitude on this point, bring the natural line of sight on the same point by turning the wheel controlling the cradle. Take two measurements, one by raising, the other by lowering, the carriage, then make the wheel fast in a middle position as above. (The cradle should always be brought to its position in the "elevating" direction.)

(*b*) For the posts equipped with the 1916 model simplified carriage, use the 1888 model level, taking the mean of two measurements, as above, and find what is the angle between the front angle iron and the natural line of sight. Then go through operation 3, using the level set at the angle obtained instead of using the 45-degree square. Then go through operation 4. If the adjustment can not be secured in this manner correct the error by a suitable shifting of the reference line of the corrections for site.

PREPARATIONS FOR COMBAT.

24. The lines of sight being verified so that the pieces are ready to fire, it is necessary that the muzzle cover and the breech cover be taken off; that the brake be cleared; that the rammer be placed near the platform; that the laying apparatus be in place; that the fuse setter or the fuse setters be in place; that about 20 shells (uncapped) be placed on the stands in immediate proximity to the fuse setter; that cases containing about 100 shells—at least 40 of which are uncapped—be set near the platform;[1] that the ammunition carriers be equipped with the necessary tools for rapidly uncapping the cartridges (in case of prolonged fire); and that the communications with the commander's post function normally. It is the duty of the chief of section to see to these preparations.

The chief of post decides, depending on the time, whether preparations for combat will be made.

DESIGNATION OF THE TARGET.

25. To designate the target, the runway should have a graduation in azimuth in 100 mils, turning counterclockwise, painted on its inner edge. The platform should be equipped with an index permitting the exact reading of this graduation. This graduation must correspond with a similar graduation reproduced on all the apparatus of the commander's post, so that when zero is laid off all apparatus take the same direction, preferably north, which facilitates the transfer of the directions on the map and the intersections with neighboring posts. To adjust the zero of the apparatus, lay them all on a certain distant point of known azimuth.

The platform should also bear two graduations for site, one permitting the reading of the inclination given the piece by the movement of the carriage,[2] the other permitting the reading of the inclination of the apparatus for laying for deflection.

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[1] For posts which do not often fire, the requirements relative to uncapping the cartridges can be modified by the local authorities, whose duty it is, in that case, to take the necessary precautions that the uncapping during fire shall not impair the good execution of the fire.

[2] There are several easy means of making this graduation, either by attaching to the end of the axle a movable index opposite a graduated circle attached to the flask of the platform or by graduating the uprights of the winch and the inner edges of the platform and reading at the level of the upper edge of the trail.

The command "220, 30°" is then sufficient to direct the piece and the two laying apparatus approximately toward the point of the heavens where the airplane has been seen and to permit the two layers to see it.

In this search for the target be careful to set the quadrant, the site corrector, and the deflection at zero.

OPENING AND CONDUCT OF FIRE.

26. As soon as the target is in sight all cannoneers must be at their post.

The chief of section makes sure that the piece is "ready for fire" (see No. 24), that the layers see the target, and that the telephonic communications are working.

He reports "First (second) piece, ready," which is repeated by one of the cannoneers equipped with the telephone.

At this moment, even before it is desired to commence fire, commands for range, altitude, speed, orientation, and secondary corrections for deflection and site may come from the commander's post. These commands must be executed by the fuse setter and the deflection and site setters, as prescribed in the School of the Cannoneer. But the fuse setter does not actually set the fuse. The layers lay continuously. The range cannoneer gives the approximate range according to the commands heard.

If there has been no command for range, the fuse setter and the deflection and site setters lay off 6,000.

The opening of fire follows the signal "Commence fire," made by whistle according to the code given below. The fuse setter sets the fuse and passes the cartridge to the loader, the range cannoneer lays off the range called by the fuse setter and repeated by the loader, the projectile is loaded, and the firer fires the gun as soon as the two pointers have called "ready." The fire continues without interruption and without precipitation, the fuse setter each time setting the fuse according to the last range heard.

Cessation of fire follows a signal by whistle (see the code of signals below). At the command "Suspend fire," the maneuver continues, the commands for range and orientation continuing to arrive at the piece. At the command "Cease fire," the fire is concluded and cartridges are prepared with a view to another fire.

The cartridges whose fuses have been set are set aside, the corrector and the range are laid off on the bracket. They will be used for trial fire. The cartridge cases which have fallen into the pit are taken out.

All commands, such as "Commence fire," "Cease fire," are made by whistle by the following code of signals:

Long blast of whistle	Alarm.
Blast of whistle (1 second)	Commence fire.
2 short blasts of whistle	Suspend fire.
5 or 6 short blasts of whistle	Cease fire.
5 or 6 short blasts followed by one long	Change of target.

In a general way, long blasts of the whistle indicate the opening of fire; short blasts indicate the ceasing of fire.

INCIDENTS OF FIRE.

27. (1) *Misfire.*—In case of misfire the firer waits a few seconds and fires again. If necessary, he does this a third time. If this is not successful, he opens the breech; if the cartridge does not fall out unaided, the firer takes the rammer, inserts it in the muzzle, and by light blows drives out the cartridge, which the loader receives and sets aside. To facilitate the handling of the rammer the layer for height, if necessary, depresses the piece. While doing this he must avoid losing sight of the target.

(2) *Replacement of personnel.*—If the personnel is insufficient, the posts which may be left vacant, *if absolutely necessary*, are the following:

Chief of section: His duties are assumed by the range cannoneer, who is able to supervise his piece.

Loader: In this case, the fuse setter is stationed at the right of the winch; the firer seizes the cartridges with his left hand when the fuse has been set and inserts them in the chamber.

Third ammunition carrier: Provided that the supply of uncapped shells within reach of the fuse setter is sufficient.

The personnel can not be further reduced without greatly impairing the rapidity of fire. In case of necessity, the next place to leave vacant is that of first ammunition carrier, the fuse setter taking the cartridges to insert them in the ogive openings.

SPECIAL ARRANGEMENTS FOR NIGHT FIRE.

28. For night fire, it is necessary to light the fiducial edges of the collimators or the reticule hairs of the telescopes, as well as the various graduations which must be read during the fire.

Failing the regulation lighting apparatus, make some by improvised means. Endeavor to dim the light as much as possible, in order not to dazzle the pointers, who must see a target which is often nearly invisible. This may be attained by means of electric lamps placed in a box with small openings so arranged as to direct the light solely on the graduations and never in the direction of the pointers.

To ascertain if the light is sufficiently dimmed, it is essential to test this device in complete darkness, giving the eyes at least five minutes to get accustomed to it.

Test the connections and the condition of the electric batteries every evening. Always have spare batteries.

During fire, the firer discharges the gun only when the word "ready" is given by the two pointers. The latter, when giving this word, must close their eyes and cover them with their hand, in order not to be dazzled by the flash of the discharge, so that they may be able to resume immediately the laying of the gun.

If the bad conditions of lighting make it difficult to execute a maneuver in a regular way, the fire commander uses the mechanisms of fire given in No. 75 of the Instruction on Fire (fire by 4, progressive fire by 100, 200, or 300).

FIRE BY SOUND.

29. When the target is not visible it may be advisable to fire by sound.

The direction and the inclination of the gun are then ordered by the fire commander, and are given to the piece by means of the graduations described in No. 25. The direction is given by the direction pointer acting on the orders of the chief of section, who watches the proper graduation. In the same way the inclination is given by the elevation pointer acting on the orders of the range cannoneer. The deflection and site setters are of no service.

Commands are given for six rounds in the form "Azimuth 52; inclination 40; up by 3," for example. The order for direction (azimuth 52) applies to the 6 rounds. The order for inclination (40) applies to the first round. The order "up by 3" means that after each round the pointer must give the wheel operating the winch 3 turns in the direction which elevates the muzzle.

The fuse setter gives the range as described in No. 26. This range is ordered by the fire commander.

Chapter II.

COMMANDER'S DETACHMENT.

"To read the regulations is not enough; they must be learned. To learn the regulations is not enough; they must enter into the reflexes of the man."

RÔLE OF THE COMMANDER'S DETACHMENT IN FIRE.

30. The commander's detachment comprises the noncommissioned officers and cannoneers necessary for determining the elements of fire and for the conduct of fire.

It is *ready for fire* when the instruments are set up and adjusted and when the communications are established between the commander's post and the guns (usually telephone), between the commander's post and the altimeter (usually speaking tube), between the altimeter and the distant posts (by telephone or by "field signalers").

INSTRUMENTS.

31. There must be enough instruments to equip the commander's post (C. P.) and two distant altimeter and observation posts (O. P. 1 and O. P. 2).

A. Posts Not Equipped With Tachometers.

Regulation apparatus furnished or to be furnished by the State workshops.—A field telemeter with automatic corrector and a 1916 model altimeter, or an altitude telemeter with auto-

matic corrector and a horizontal distance telemeter which can operate as an altimeter. (The two apparatus together make it possible to measure either the altitude and the distance or the horizontal distance if the fire is at a small altitude. (See No. 69.))

For designated posts: A model 1916 orientation telescope with wind disk, a model 1916 altitude tachoscope.

Regulation apparatus to have made in the parks or in the units.—A wire altimeter with observation screen (see No. 41 and Appendix II), a set of observation screens to complete the altimeter furnished by the State (see No. 49), four tubes with luminous slits or knotted cords for night fire (see No. 52).

Failing a 1916 model tachometer, a makeshift tachometer for wind (see No. 38) should be made. Failing a regulation wind disk, a makeshift wind disk (see Appendix III) should be made.

NOTE.

(1) Certain altitude telemeters no longer have an automatic corrector. Those which have a site corrector are accompanied either by an independent sitogoniograph or by a set of tables. Those which no longer have a site corrector may be provided with a laying wheel or be completed by tables giving the corrected range. (See Instructions on fire, Chapter IV.)

(2) The 1916 model altimeter is given only to certain posts. In default of it substitute for the "1916 altimeter set of screens" combination either a second wire altimeter with screen or a set of screens and a field or fortress altimeter used as an altimeter but independent of the fire-conduct telemeter.

Failing an orientation telescope, put an experienced noncommissioned officer in charge of estimating the orientations with the aid of a good field glass.

Nonregulation apparatus the use of which may be authorized.—There are numerous nonregulation apparatus, certain of which are well constructed and can be used (the altimeters based on what is called the "flag" principle are particularly to be noted), but under the express reservation that authorization for their use shall be asked of the Inspector General, who shall appoint a member of the Commission for Practical Studies to examine whether their construction affords all the desired guarantees of exactitude.

B. Posts Equipped With Tachometers.

The place of the orientation telescope, the tachometer, and the altitude telemeter is taken by a single apparatus, called a teletachometer, operated by five men, and on which is read the future fuse-setter range, the correction for deflection, and the correction for site.

As this apparatus is not yet in service, it will not be further discussed in these present regulations, but at the proper time it will be made the object of a note giving instructions for its operation.

COMPOSITION OF THE COMMANDER'S DETACHMENT.

32. The commander's detachment is divided as follows:

(1) *C. P. fire-conduct platoon*—

Fire corporal, 1 corporal, chief of the platoon.

Fire conduct telemeter, 1 corporal, equipped with a telephone, and 2 men.

Orientation telescope, 2 men.

Wind gauge, 1 man (except for posts where the platforms are equipped with wind disks).

Tachometer (if any), 1 man.

Telephone central or order transmitter, 1 man.

(2) *C. P. observation and altimeter platoon*—

(*a*) Wire altimeter and screen united to the altimeter,

1 N. C. O., chief of platoon, reader.

1 pointer.

1 observer.

1 transmitter.

(*b*) Altimeter and screen separated from the altimeter.

Screen: 1 N. C. O., chief of platoon; 1 observer.

Altimeter: 1 pointer, 1 reader.

(3) *O. P. 1 and O. P. 2.*—Each post:

Screen: 1 corporal, chief of post.

Altimeter: 1 pointer, 1 reader.

Note.—In two-gun posts the observation and telemeter platoon is placed under the special supervision of the second lieutenant, who frequently visits the observation posts to assure himself that the personnel of these posts are making proper use of the apparatus.

DUTIES OF THE PERSONNEL OF THE COMMANDER'S DETACHMENT.

C. P. FIRE-CONDUCT PLATOON.

1. FIRE CORPORAL.

33. *Duties.*—(*a*) Note all information concerning the fire on sheets lined in advance.[1]

(*b*) Supervise the execution of the service in the whole fire-conduct platoon.

2. FIRE-CONDUCT TELEMETER OPERATORS.

34. *Duties.*—To determine the fuse-setter range and to send it to the fuse setters.

(A) Post equipped with the 1916 model field telemeter automatic corrector.

Nomenclature: This apparatus comprises, besides the parts of the 1915 model telemeter, a *slide* and a *scale* for *secondary corrections*, an *attachment for orientations*, a *movable rule* working on this attachment, a *beveled alidade* which has a reference mark for speeds, and a circle with a *graduation for speeds.*

Personnel.—One corporal reader (equipped with a telephone with headpiece, communicating with those of the fuse setters); one pointer; one site setter.

Erection and adjustment. (*See* Appendix 1.)

OPERATION.

(*a*) *Duties of the pointer.*—Lay in direction and altitude on the target.

The laying for altitude must be precise, the laying for direction need only be approximate.

(*b*) *Duties of the site setter.*—(1) To lay off the speed. (2) To lay off the orientation. (3) To lay off the secondary corrections for site.

(1) *To lay off the speed.*—At the command "speed so much" (for example, "Speed 35"), slightly loosen the binding screws which hold the beveled alidade immovable; move this alidade to read the speed commanded; tighten the binding screws again lightly.

(2) *To lay off the orientation.*—At the command: "Coming (going) + (—) so much," for example, "Coming+30," move the handle controlling corrections for site so as to bring and keep

[1] See p. 112 for footnote.

[1] EXAMPLE OF THE FORM OF THESE SHEETS.

Section of semistationary post No. ——. Date: ——. Hour: ——. Duration of fire: ——. Nature of the target: ——. Short note of the course of the target: ——.

Speed.	Altitude.	Orientation.	Nature of fire.	Ranges.	Corrections for deflection.		Corrections for site.		Lateral observation.		Corrections for altitude.		Corrections for speed.		Observation.
					Add.	Subtract.	Up.	Down	C.	L.	Add.	Subtract.	Add.	Subtract.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

[1] See p. 112 for footnote.

the corrugated edge of the movable rule on the intersection of the bevel edge of the rule with the curve corresponding to the orientation announced "Coming 30."

(3) *To give the secondary corrections for site.*[1]—At the command "drum so much," for example, "Drum 75," given by the cannoneer gauging the wind[2] and repeated by the telephone central, lay off the correction prescribed by bringing the secondary correction slide opposite the corresponding graduation. If this graduation starts at zero, subtract the number reported from 100. In the example chosen, instead of 75 the number 25 will be laid off.

(*c*) *Duties of the reader.*—(1) To lay off the altitude. (2) To lay off the altitude corrections. (3) To give the range. (4) To report the altitude to the telephone central at each important change (of more than 200 meters).

(1) *To lay off the altitude.*—At the command "Altitude so much" (for example, "Altitude 2,000"), which comes to him either from the altimeter or, if the altimeter is not working, from the fire commander, he moves the altitude slide with the right hand, the thumb pressing on the checkered button so as to ungear it, and lays off the altitude commanded.

(2) *To lay off the altitude corrections.*—At the command "altitude, plus or minus so much," take hold of the ballistic slide with the right hand and move it in the desired direction for the distance indicated, guided by its graduation.

Principal diameter, with an elbow, having a fixed central sighting point and a movable sighting point on a slide which runs along a graduation in wind-velocities.

Vertical altitude rod, which holds the screen, graduated from 1,000 to 4,500, and held by a split sleeve which itself has an adjusting nut.

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[1] The posts equipped with field telemeters generally make "observation for altitude." The secondary corrections for site commanded for the gun should therefore be laid off on the telemeter. (See Instructions on Fire, of Aug. 15, 1916, No. 61.)

[2] When the platforms are equipped with wind disks the cannoneer gauging the wind is omitted. In that case—

(1) Lay off on the secondary corrector the corrections of adjustment prescribed by the fire commander.

(2) It is possible to allow for the wind by an altitude correction (see Instructions on Fire, of Aug. 15, 1916, No. 61) which the layer of the telemeter can read on a disk similar to the wind disks and attached to the foot of the telemeter. But this precaution is useful only if the wind is high and the altitude is measured with precision.

Horizontal-distance rail, which turns about the rod and has a rider carrying a sighting peephole.

Tripod.—Each apparatus is accompanied by a metronome and a *calculating device*.

Men necessary.—One man to work the calculating device.

Setting up the apparatus.—The rail has a level. Set the rail first perpendicular, then parallel to one of the sides of the triangle formed by the three points of the tripod. In each of these two positions, center the bubble between its marks by moving the feet. Repeat this operation if necessary. Place the metronome inside the tripod. During fire open the metronome and start the pendulum which strikes the seconds.

USE.

Laying.—Take hold of the rider from below, between the thumb and the two first fingers of the right hand, being very careful not to press it up or down in order not to bend the rail.

Lean the right temple against the peephole so that the eyeball is at the height of the center of the peephole.[1]

The apparatus is laid when the sighting point which is suitable for the measurement (see below) is seen in line with the target. To lay for direction, turn the rail about the altitude rod. To lay for height shift the rider back or forward on the rail.

(1) *Measurement of the wind by means of a smoke ball from burst at a known altitude* (see Nos. 38 and 39 of the Instruction on Fire).—Set the principal semidiameter, which has no slide, so that it points south (lay off this direction by a stake planted 30 or 40 meters from the tachometer). Set the altitude rod at the altitude of the smoke ball, 3,000, for example, by first loosening and then tightening the adjusting screw by a fraction of a turn. Lay the tachometer on the smoke ball by the central sighting point. Do not touch it again. Count up to 20 at the cadence marked by the metronome. At 20 compare the position of the smoke ball with that of the three circles of the screen. These circles, for a duration of 20 seconds, correspond respec-

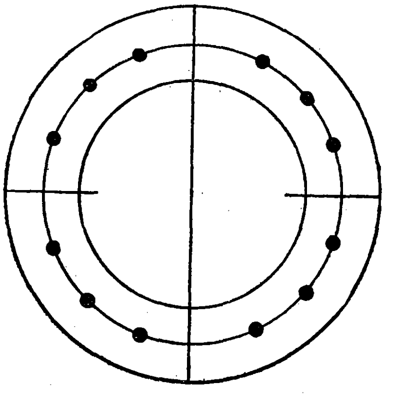
[1] The tachometer operator must be trained by his instructor to take the desired position himself mechanically. (It is well to put rubber around the peephole.) It is equally satisfactory to press the eye to the peephole and look through the peephole. The only important thing is that the distance of the eye below the screen should remain constant, within 2 or 3 centimeters.

4069°—17——8

tively to the velocities of 15, 20, and 25. From this deduce the velocity of the wind.[1] Determine the direction of the wind, taking the south point as origin, by means of the two diameters and the beads of the central circle. Report the wind in the usual form, for example, "Altitude 3,000, wind 15, speed 12."

(2) *It being supposed that the altitude is known, to measure the actual airplane speed.*—Orient the principal diameter in the direction of the wind by rotating the altitude rod, using the graduation in tens of degrees on the beveled edge of the split sleeve.

Shift the movable sighting point in the direction contrary to the wind (see figure) and for a space proportional to the



South

velocity of the wind, using the graduation on the principal diameter.

Set the vertical rod at the altitude given by the altimeter or by the fire commander.

Lay the tachometer on the airplane, using the *movable* sighting point.

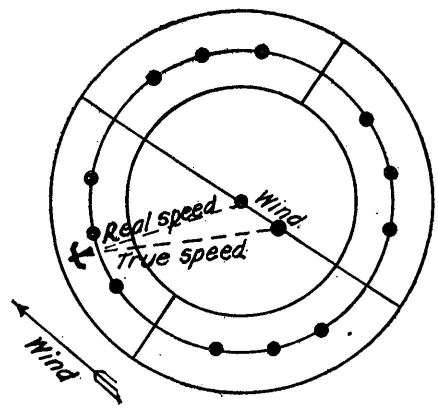
Starting from a tick of the metronome, do not touch the tachometer while counting up to 10 in cadence with the metronome.

[1] Certain models have a supplementary circle corresponding to the velocity 5, which should be added to the others to determine the wind.

At the tenth tick read the speed on the screen, remembering that the 3 circles correspond, respectively, to the speeds 30, 40, and 50 (for a time of 10 seconds).

If the airplane makes a loop during the measurement, break off the operation and take a new measurement. Go to the fire commander and give him the speed in the form[1]: "For altitude 3,000, speed 38" or "descending, speed 42," if the airplane seems to be descending; or "ascending, speed 30," if the airplane seems to be ascending.

Keep informed of the altitude, and continue to take the speed during the whole fire.



South

Case where the horizontal distance to the airplane is more than 6,000.—The horizontal-distance rail is now not long enough to permit sighting, and as the airplane is farther away it is advisable to increase the time during which one operates. Set the vertical rod at a middle altitude. Operate as before, but count up to 20 (20 seconds) instead of up to 10.

(3) *Verification of the wind.*—The wind can be verified at any moment on any round of the real fire. It is only necessary

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[1] It will be remembered (see Nos. 9, 55, and 56 of the Instruction on Fire) that if the altitude of the fire is not 3,000, the fire commander must increase the speed in the same proportion as the altitude. At the altitude 3,500 an increase of 400 meters in altitude corresponds to an increase of 4 meters in speed. At the altitude 1,800 an increase of 400 meters in altitude corresponds to an increase of 8 meters in speed.

to lay on one of the smoke balls of a burst with the movable sighting point. At the end of 10 seconds the smoke ball should be seen on the central point. In case it is not, correct with the eye the direction and the velocity of the wind. Report them in the regular form to the wind gauger.

(4) *The actual airplane speed being estimated as prescribed and the altitude being unknown, to measure the altitude.—First process:* Set the tachometer at the estimated altitude given by the fire commander (half altitude if the horizontal distance is too great), say 2,500. Measure the actual speed as if the altitude were exactly known, say 28 meters. Lay off on the calculating device the division "speed 28" above the division "altitude 2,500." Read the altitude below the estimated speed, for example, 3,100 below 35. If the airplane has made a loop, or if it apparently has not kept a horizontal course, cancel the measurement and begin again. The altitude having been corrected by adjustment, keep it up to date and measure the actual airplane speed as described in 2 of this No. 37.

Second process: For velocity and direction of the wind, take those which agree with the estimated altitude of the airplane. Lay them off on the apparatus as described above. Set the vertical rod at altitude 1,000. Lay on the airplane with the movable point. Do not touch the tachometer.

The estimated speed of the airplane being 35, count the number of seconds which elapses until the airplane crosses the imaginary 35 circle, say 32 seconds. Multiply the number obtained by 100, and report the result in the form: "Altitude for speed 35, 3,200." Cancel the measurement if the airplane makes a loop or if it does not seem to be moving in a horizontal course.

Set the vertical rod at 3,200, then at the successive altitudes given by the adjustment, and measure the actual airplane speed regularly, as above.

This process is particularly suitable for distant airplanes, as it permits operating over a considerable period of time, which compensates for the lack of precision due to the distance. Instead of setting the rod at 1,000 meters altitude, it can also be set at 2,000 or 3,000, multiplying by 200 or 300 the number of seconds obtained. The process loses in precision, but gains in rapidity.

MAKESHIFT TACHOMETER.

38. All posts which do not have a 1916 model tachometer should have a makeshift tachometer for determining the wind. This tachometer is described in No. 34 of the Instruction for Fire.

The proportion r/a (see No. 38 of that instruction) being taken equal to 1/10, it is only necessary to divide the number of decameters of altitude for the time γ to obtain the speed w.

For the direction, always set one of the diameters of the tachometer to the south and estimate the direction of the wind in grades, as just described in No. 37.

6. Telephone Central.

39. *Post.*—Beside the fire commander, preferably in a trench, to improve the acoustics of the telephone.

Duties.—(*a*) Before fire, establish the lines of communication between the commander's detachment and the guns; (*b*) during fire, transmit the commands to the guns.

(*a*) *Before fire.*—Establish the lines of communication between the commander's detachment and the guns.

The communications to be established are the following: (1) Communication between the telemeter operator and the fuse setters; (2) communication between the telephone central and the deflection and site setters.

The communications should be established in such a way as to operate regardless of the direction of the fire. Use double wires. Pass the ends of the wires at the gun under the runway and to the bottom of the hole, coil them around the circular socket block, lead them up on the platform, leaving slack enough for it to rotate, carry the end of one line to the fuse setter, split the other and carry it to the deflection and site setters. (This way of arranging the lines is given only as an example. Other arrangements may be used, provided they work well.)

Double earpieces, held tight against the ear, make it possible to hear the commands without being interfered with by the sound of the gun.

(*b*) *During fire.*—Transmit to the deflection and site setters the commands given by the fire commander and by the wind gauger, as well as the altitudes reported at each important change by the telemeter operator.

At each alarm the guns report that they are ready in the form: "First gun ready; second gun ready." Report this to the fire commander.

Observation and Altimeter Platoon.

FIRST CASE—WIRE ALTIMETER WITH OBSERVING SCREEN.

40. The wire altimeter has the great advantage of allowing, at one time and with the same apparatus, observation and altimeter reading. It is to be considered as the normal apparatus for semistationary posts. Its operation will therefore be the first described.

NOMENCLATURE.

(See figure.)

41. For dimensions, sketches, erection, see the Appendixes.

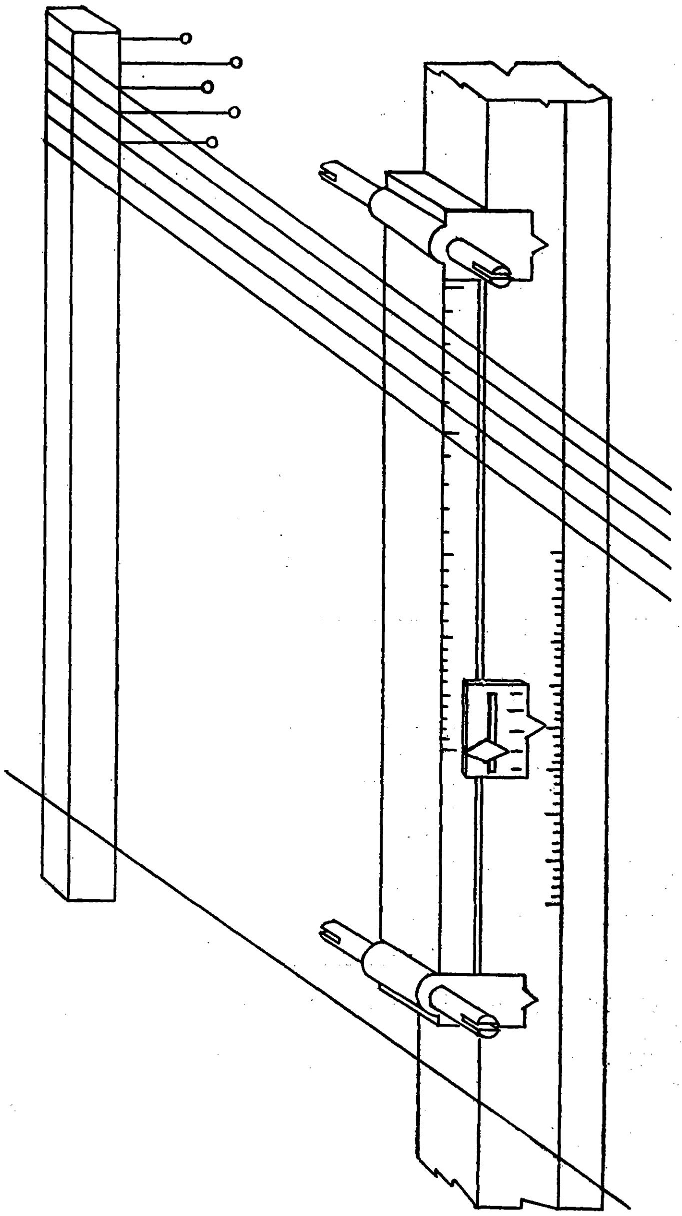
Fixed rule, parallel with the base, bearing some kind of scale, which must be the same for the C. P. (command post) and the O. S. (observation station). The rule at the C. P. has a *true-altitude rider*, graduated in multiples of 10, on either side of a zero, the intervals between the lines being equal to that of the wires of the screen (see below). Sliding on this rider is an *index of ballistic altitude*, the position of which on the rider is determined by the quantity given by the calibrated observation. The ballistic altitude is read immediately underneath this index.

The rule at the C. P. and the O. S. has a *small rule* passing over the riders and borne by two straps fitting about the fixed rule which can slide the whole length of the fixed rule. At either end of the small rule there are *two aiming sights*, the *layer's sight* at the C. P. side, and the *observer's sight* at the O. S. side. The small rule of the C. P. is graduated in altitudes.[1]

The small rule of the O. S. has at the middle a *reading index* (the scale on the fixed rule is, of course, adjusted to allow for a length equal to that separating the index from the layer's sight).

The fixed rule is placed in a trench about 1½ meters deep (posts within artillery range of the enemy). Arranged per-

[1] In case the C. P. is connected with two O. S., one at either side of the C. P., the small movable rule has a graduation on each side. Passing from one O. S. to the other, the places of the layer and the observer are reversed. The altimeter of the C. P. is equipped with two screens, one on either side of the central wire.



pendicular to the base, and about 30 or 40 centimeters above the rule, are the following:

First, the *layer's wire*. This wire has, at intervals of 50 centimeters, little knots of string, called designation marks. The central knot is set just above the rule. It is called the zero mark. The other marks are designated by "forward 20" or "back 30," according as they are on the enemy side or the opposite side, the interval between two marks being considered as equivalent to 10.

Second, an *observation screen* (eventually two screens, see No. 40, above) formed of 5 wires stretched parallel to the layer's wire and at the same level. The central wire is set so that it is separated from the sighting wire by a vector equal to that separating the two aiming sights, the separation of the wires being made such that it corresponds to a variation of altitude of about 200 meters when h=2,500 (this variation is to be taken for the scale of altitudes).

OPERATORS NECCESSARY.

43. For each post, 3 men—an operator, a layer, and an observer.

The operator at the C. P. is chief of the altimeter and observation platoon. This duty should be entrusted to the officer second in command or to a chosen noncommissioned officer. The two operators and the two observers are joined in pairs by telephones with headpieces. The lines should be distinct, and should not follow the same course, so as to avoid induction and simultaneous interruption. In case of shortage of apparatus, only the two operators have this telephone connection.

When the altimeter of the C. P. is remote from the altitude telemeter and can communicate with it only by speaking tube (an arrangement which is highly recommended) it is well to add a transmitter to the personnel of the C. P. platoon.

OPERATION.

43. (*a*) *Case where the operators and the observers are joined in pairs by telephone with headpieces.*

(1) *Layer.*—Keeps the aiming sight and the sighting wire continuously laid on the target.

(2) *Observer.*—Puts his eye to the observation sight and watches the bursts, paying no attention to the airplane, which

must always be on the central wire if the apparatus is well adjusted.

The rounds are reported: "Short 10," "Over 12,"[1] the interval between two wires being taken as 10, and the rounds being reported "short" or "over" according as they are seen on the side toward the other post or on the opposite side. (See Instruction on Fire, No. 62.)

First case: Observation by rounds of fire by piece with a single gun.

As soon as the observer at the distant post sees a burst he calls "Pan," and then "short (or over) so much."

If, when "Pan" is called, the observer at the C. P. does not see the burst, the combined observation has not succeeded, and he pays no attention to the observation received.

If, on the contrary, he sees the burst he reports to the chief of platoon operator both the observation which has been transmitted to him by his fellow observer and his own observation in the form "short 20, short 5" or "short 12, over 4," it being the duty of the operator to perform the addition or subtraction.

Second case: *Observation by average in the case of fire with two guns or of fire by series with one gun.*

The observer at the C. P., who is informed of the mechanism of fire employed, warns his fellow observer by the word "average." The distant observer repeats "average," and then calls "pan" when he begins to observe, "hip" 12 or 15 seconds later, and then "over (or short) so much," his report of observation referring to the average of observation made between the signal "pan" and the signal "hip." He gives the C. P. observer a small interval of time in which the latter reports to the operator the average received and the average observed, in the form "short 18, over 6." They then open and close with the same signals a new period of observation, and so on.

(3) *Operators.*—The O. P. operator reads and reports by telephone in advance the division of the fixed rule which he thinks must be laid off 3 or 4 second later. He reports it in the form "such and such division, top," using only the last digits of the number read, as for example, "80" (instead of "280")

[1] For low altitudes, estimate only multiples of 5; for high altitudes, multiples of 2. This difference is due to the fact that the interval between two wires corresponds to a difference of altitude proportional to the square of the altitude, and the difference is therefore much greater at high altitudes (400 meters and over in the case considered).

"top," the signal "top" being given at the precise moment when the division mentioned arrives in front of the reference mark.

The P. C. operator.—Determination of the true altitude: At the signal "such and such division" set the rider for true altitude opposite the division indicated. At the signal "top" read the true altitude opposite the zero of the rider, and call it out to the operator of the altitude telemeter (or to the transmitter), in the form "measured altitude, so much." Send new reports only when the altitude changes more than 100 meters (50 meters for low altitudes).

Determination of the ballistic altitude.—As the operator at the C. P. is chief of the altimeter and observation platoon, he tells the observers whether to observe round by round or by average. On the report "Short 12, over 4" he deduces that the shots are 8 short. If the observation is made by rounds, he waits for two or three other reports, takes the average, and moves the ballistic index to correspond. If the observation is made by average, he moves the ballisitc index immediately by the algebraic sum of the numbers reported.

From the moment the ballistic index has been shifted the desired distance,[1] he sends the operator of the altitude telemeter the corrected altitudes in the form "corrected altitude, so much," the word "corrected" not being repeated thereafter.

He must be sure to observe the "waiting period" prescribed in No. 67 of the Instruction on Fire before again taking account of the *total* of the variations reported.

When the observations have too little agreement, they should be ignored.

(*b*) *Case where only the operators are connected by telephone.*—The same line must serve both for the altimetry and the observation. To avoid confusion, the following procedure will be observed:

Principle of the process.—Take continuous altimetric measurements until the burst of the first rounds. At that moment, yield right of way to the observation for 12 to 15 seconds. Then immediately resume the continuous measurement of the

[1] It is to be noted that the shifting of the ballistic index gives a correction of altitude proportional to the *square* of the altitude, and not proportional to the altitude. In case of very marked diminution of the altitude (at least 1,000 meters), it may be advisable to increase the movement of the rider by the eye.

altitude, remembering that the observations taken during the waiting period are generally not used, and that the ballistic distance varies slowly.

At the end of a period of time T (see Instruction on Fire) counted roughly, again reserve the telephone line for communications relative to the observation.

Execution.—Until the first bursts, continuous altimetry, as in case (*a*). At the first burst, the observer at the O. S. calls "Pan," and then sends observations for each round or by average, as per the orders given by the chief of platoon, for about 12 seconds. He announces the end of the observation period by the signal "hip." During all this period, all his reports have right of way. The operator at the C. P. repeats without loss of time the "pan" and the "hip" of the O. S. and receives the reports of the two observers. Immediately on the signal "hip," observation ends and continuous altimetry is resumed. The latter is interrupted only on the command "Observe," again given, when necessary, by the chief of platoon. This command is followed by a "pan" and a "hip," which define for the observer at the C. P. the commencement and close of the new period, etc.

DESIGNATION OF THE TARGET.

45. *Designation within the C. P.*—If the altimetry C. P. is near the C. P. of the commander, and if the airplane is not immediately visible, the chief of the altimetry platoon goes to the fire commander to receive the designation. If the contrary is the case, set up, in the prolongation of the trench containing the altimeter, a rough apparatus made of a wooden rule with two sighting points, revolving around a horizontal and a vertical axis like a battery telescope. By means of a graduation for azimuth and for site, the airplane can be found.

If there are many airplanes, the airplane is designated by the fire commander in the form of a fraction, for example, 2 over 5, the airplanes being numbered from the top downward in terms of their site. (It is generally well to take the highest as objective, as there are many chances that it is the nearest.)

Designation at the observation station.—The layer or the observer (whichever has seen the airplane) places himself at his observation sight, lays it on the airplane, and reports its position relative to the reference marks (reference marks on the middle wire of the screen or on the altimetry wire) in the form "forward 24" or "back 12."

If several airplanes are projected in the region of the wire, he completes the designation by giving a fraction (for example, "1 over 5"), it being understood that the number 1 is the airplane which is nearest the zero mark (it follows that an airplane which is numbered 2 over 5 by the C. P. may be numbered 1 over 5 when reported by the O. S.).

The operator at the C. P., who should already have put on his headpiece and have given the alarm to the O. S., looks at the division of the rule which corresponds to the estimated altitude, 280 for example, and reports "airplane 280, forward 24, 1 over 5."

If the O. S. reports "not seen," he again determines the coordinates of the target in the manner just described and sends them to the O. S. until the latter reports "seen."

Second Case.

Altimeter Apart From the Observation Screen.

ALTIMETRY APPARATUS.

46. *1916 model altimeter—Men necessary.*—At each post, one operator and one layer. The two operators are joined by telephone apparatus with headpieces.

(*a*) *Erection.*—See No. 19 of the Instruction on Fire and Appendix I.

(*b*) *Designation of the target to the distant observer.*

At the C. P.—The layer lays instrument on the target. The operator moves the protractor until its alidade cuts the central alidade[1] on the horizontal corresponding to the probable altitude reported by the fire commander. He reads and transmits to the distant observer the angle read on the protractor and the angle read on the graduation surrounding the telescope in the form "215—telescope 30."

At the O. S.—The operator has the two angles marked as received. The layer, with the naked eye,[2] looks for the target in the region toward which the telescope is pointed. Report "Seen" or "Not seen" to the C. P. If the airplane is one of a

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[1] On each alidade take the edge which passes through the axis of rotation.

[2] The process is not sufficiently precise to enable the airplane to be located in the field of the telescope.

squadron, complete the designation by sending a fraction, 2/5, for example, and in the way indicated in No. 45. This makes it necessary to establish near the altimetry post a wire parallel to the base. However, as far as the C. P. is concerned, as a substitute for the wire the layer may stoop and count off the number of the airplanes from the upper edge of the plate which has the altitude horizontals.

(*c*) *Measurement of the altitude of the target.*—Immediately on sighting the target, *without any interval*—

At the O. S. the layer lays the instrument on the target. The operator reads and reports by telephone in advance the division of the protractor which he thinks will be laid off at the end of five seconds, and sends a " top " at the moment when it is laid off, preceding it with the word "Attention."

At the C. P. the layer lays the instrument on the target, being particularly careful to have the instrument truly laid after the word "Attention" is called. The operator lays off on the protractor the division called. He fixes his eyes on the intersection of the two alidades. At the signal " Top," he reads the altitude on the graduated disk. He reports it to the fire commander in the form " Measured altitude, 3,500." He then proceeds without delay to a new measurement.

FIELD TELEMETER USED AS AN ALTIMETER.

47. *Remark 1.*—During fire the field telemeter should not be employed as a fire conduct telemeter (to convert altitudes into future fuse-setter ranges) or as an " indirect altimeter." (See Instruction on Fire, No. 20.)

Posts which have only one field telemeter should therefore install two altimeters independent of the altitude telemeter. In case there are none on hand at the time, use the process of No. 65 of the Instruction on Fire (continuous adjustment), i. e., measure the altitude before fire is opened and keep it constantly corrected by continuous adjustment. But this process is only a *last resort,* and can not give as good results as keeping the altitude constantly corrected by continuous altimetry, observation in this case having no other object than to give the *ballistic error*, either before fire (trial rounds), or during fire, or both before and during fire.

Remark 2.—Field telemeters are equipped with a metal triangle or a parallax circle and a slide rule, or, more generally, with both.

When the metal triangle has no play, it is used in preference to the parallax circle on all telemeters used as continuous independent altimeters. In the contrary case, and for all altimeters used normally as fire conduct telemeter and exceptionally as altimeter, the parallax circle is used.

Number of men necessary.—At each post one layer and one operator. The two operators are connected by telephone with headpieces.

Erection.—See Appendix 1.

Operation—(a) Designation of the target to the O. S.—At the C. P. the layer lays the instrument on the target (especially for direction). The operator reads the site angle. He places the rectilinear edge of the protractor on the approximate distance given by the fire commander. He reads the probable azimuth of the airplane seen from the O. P. He determines its probable site by comparing the two sides of the triangle formed on the apparatus. If the side corresponding to the O. S. is longer than the side corresponding to the C. P., this means that the site measured from the O. S. is less than the site measured from the C. P., and vice versa.[1] He sends the O. P. the azimuth, and the probable site thus obtained in the form "355—site 40 degrees."

The operator lays off on the apparatus the data received from the C. P. (For this purpose, a graduation for site, in units of 10, must be constructed on the apparatus of the distant post.)

The layer looks in the direction indicated and reports "seen" or "not seen." In the latter case, repeat the designation.

(*b*) *Measurement of the horizontal distance* Δ.—*At the O. S.*, the layer sights on the target (especially for direction) and

[1] Apparatus equipped with parallax circle. Make the above triangle with two strings, one attached above a pin soldered under the index for readings, the other attached to the axis of the telemeter and having three knots spaced at an interval equal to the interval separating the pin from the axis. Estimate the distance in multiples of the base. After making the triangle, turn the parallax circle so as to place the radius which goes from the center to the zero division parallel to the side of the triangle corresponding to the O. S. Read the azimuth and send it to the O. S.

follows it as regularly as possible. The operator reads and reports in advance the azimuth which he thinks should be laid off at the end of five seconds (340, for example), and calls "top" at the precise moment the figure read passes the index.

At the C. P., the layer follows the target very exactly in direction and site. The operator lays off the angle sent him by the operator at the O. S., follows the distance Δ, and calls it out at the signal "top."

(*c*) *Reading of the altitude h.—At the C. P.*, the operator transfers Δ to the screen of the telemeter, reads *h*, and reports it in the form "measured altitude 3,500." Without interruption, he continues to measure a new horizontal distance, from this the new altitude, etc.

In case the telemeter is equipped with a parallax circle, the operator at the C. P., at the report 340, sets the division 340 of the parallax circle opposite the base index (fixed index). At the signal "top" he reads the parallax opposite the index prolonging the toothed arc, say 120, and the angle of site, say 32°. He lays off the parallax 120 above the azimuth 340 and reads the altitude over the site 32°. The base should have been laid off beforehand on the slide rule. To do this loosen the nuts which hold the upper rule. Set the divisions in parallax of the slide opposite the divisions in azimuth of the lower rule. Move the upper rule so as to set the number representing the base immediately underneath the site 45°. Then tighten the nuts.

NOTE.—See Appendix for procedure when the altitude of the airplane is less than 1,000 meters.

LONG-BASE TELEMETER AND 1915–MODEL ALTITUDE TELEMETER.

48. The operation of these apparatuses requires—

At the C. P., for the long-base telemeter, one corporal (operator), one layer; for the altitude telemeter, one operator, one layer.

At the O. S., apparatus of distant post, one corporal (operator), one layer.

(*a*) *Erection.*—See Appendix 1.

(*b*) *Operation of the long-base telemeter and the altitude telemeter.*

(*A*) *Designation of the target to the distant post.*—Proceed as with the field telemeter.

(*B*) *To measure the altitude of the airplane.*—O. S., proceed as with the field telemeter. C. P., *long-base telemeter:* The layer proceeds as with the field telemeters. The operator measures the horizontal distance as described for the field telemeter. In addition, he repeats the word " top," and informs the operator of the altitude telemeter of the distance read.

C. P., altitude telemeter: The layer lays the instrument on the airplane for height. At the signal " top," he holds the apparatus still in the position in which it is until the altitude reading is taken. He then repeats laying the instrument. The operator measures the altitude according to the horizontal distance indicated by the telemeter operator and reports it to the fire commander as described for the field telemeter.

APPARATUS FOR OBSERVING.

49. *Observation screens.*[1]—See No. 62 of the Instruction on Fire. The process most highly recommended for platforms is that of the wires stretched over a trench. A horizontal wooden rule, similar to that of the wire altimeter and against which the temple is pressed, makes it possible to hold the eye at a constant height. It is best to set the wires at 3-centimeter intervals and take the product of a and b equal to 900. (Notes to No. 62 of the Instruction on Fire.) Then solve the formula $\triangle h = \frac{n}{10} \times \frac{dh^2}{ab}$ by means either of a double-entry table or of logarithmic slide rule, remembering that an interval equals 10, and that n is the algebraic sum of the numbers reported by the two observers.

For $a\ b = 900$, $d = .03$, the following table is used.

h \ n	10	20	30
1,000	50	50	100
1,500	100	150	200
2,000	150	250	400
2,500	200	400	600
3,000	300	600	900
3,500	400	800	1,200
4,000	550	1,000	1,600
4,500	650	1,350	2,000

[1] The Instruction on Fire authorizes in certain cases the use of processes other than the screen process for adjusting the range (rakes, knotted ropes, etc.). The instructions given there are sufficiently detailed so that it is not necessary to repeat them.

Designation of the target.—To receive the designation of the target the observer at the O. S. goes to the distant altimetry post.

COMBINED OPERATION OF THE ALTIMETER AND THE SCREEN.

50. The operation is similar to that described for the wire altimeter.

First case.—The altimeter operators and the observers are connected in pairs by telephone with headpieces. The lines are independent. There is no difficulty. The true altitude is sent continuously to the operator of the altitude telemeter. The reports of the observation are sent to the fire commander in the form "short (or over) so much." The chief of platoon decides if the observation is to be made round by round or by average. He uses the signals "pan" and "hip" to mark the beginning and end of each period. Each period of observation lasts 12 or 15 seconds, and is followed by a waiting period, during which the chief of platoon keeps the observations received, or at least takes account only of their differences with the preceding observations (if these differences are notable). (See No. 67 of the Instruction on Fire.)

Second case, only one telephone line.—Only the altimeter operators are connected by telephone with headpieces. They operate the altimeter continuously until the appearance of the first burst, which is signaled by the observer to the altimeter operator of the O. S. by the word "pan." During the 12 or 15 seconds following this "pan," the altimeter operator stops sending the "top" reports, and transmits the reports of the observer (3 or 4 reports of single rounds, or one report of average, covering a period whose beginning and end are marked by the signals "pan" and "hip."). The altimetry is immediately resumed, and observation is not taken up again until the end of a time equal to at least five times the number of kilometers of distance, this latter being given in the nearest higher round number.

USE OF SIGNALERS.

51. In regions where telephone lines are frequently broken field matériel is issued to the posts (small 24 cm. searchlights), which make it possible for them to establish visual communi-

cation, either between the C. P. and the O. S., or between two points connected by telephone with these latter.

Communications are sent by the following code of signals:

CODE OF SIGNALS.

Calls or errors	Series of two dots .. ..
Request for steady fire.	Very long dash ————————
Not working well	Letters T.M.O.Ch. ----------
Airplane	Letter A .—
Operate altimeter	———— prolonged dash
Attention, top	—.—.
One (I)	.
Two (II)	. .
Three (III)	. . .
Four (IV)	.—
Five (V)	—
Six (VI)	—.
Seven (VII)	—. .
Eight (VIII)	—. . .
Nine (IX)	.— —
Zero	— —
Observe	———— ———— two prolonged dashes
Short	. . . . (4 dots)
Over	— — — — (4 dashes)
Understood (sn)	... —. or simply (e) .
Airplane seen	Repeat airplane (.—)
Fire terminated	(Like the whistle signal) . . . .
Change target	(Like the whistle signal) . . . . ———
Day terminated (come in).	Letter R .—.

By the use of these signals it is possible under favorable conditions to take altimetric measurements by field signalers. The signal "attention, top" *precedes* the sending of the number by the O. S. At this signal the two layers stop following the airplane during the time necessary for the readings. Only the two last figures (or the last figure) of the number read at the O. S. are sent to the C. P.

There are similar conventional signals for the designation of the target. Always use numbers. For the wire altimeter, take

as central mark the number 40 to avoid sending the words "forward" and "back."

When firing with signalers, in principle make continuous altimetric measurements. The signalers are operated by the observers.

The signal "operate altimeter" not preceded by the signal "airplane," signifies that altimetric measurements are to be taken of a trial round.

The signalers should also throw the Morse code.

FIRE WITH TRACER SHELLS AND NIGHT FIRE.

52. For fire with tracer shells, and as described in No. 82 of the Instruction on Fire, replace the observation screens, both at the O. S. and the C. P., by a knotted cord stretched parallel to the base, and at the height "*a*" above the observer's eye.

At night these knotted cords can be seen only in very clear weather or if they are projected on a very well-lighted dirigible. If the distant observer does not see how far the rounds are short or over, he must in all cases call them short or over, according to what is said of "approximate ranging" in No. 82 of the Instruction on Fire.

It is possible to create a basis for an estimate in the sky by adjusting the two guns of the platoon, if necessary, at 400 meters difference in altitude. (Note 1 to the above-mentioned No. 82. Report the error of the lower trajectory.) It is also possible to replace the knotted cord by a horizontal tube lighted inside and allowing for the escape of the light through small equidistant openings. Be careful not to let more light escape than necessary in order to see the slits, so that the target will have all visibility possible (if necessary, paste paper over the slits). In general, and for the same reason, reduce the lighting of the apparatus to the minimum.

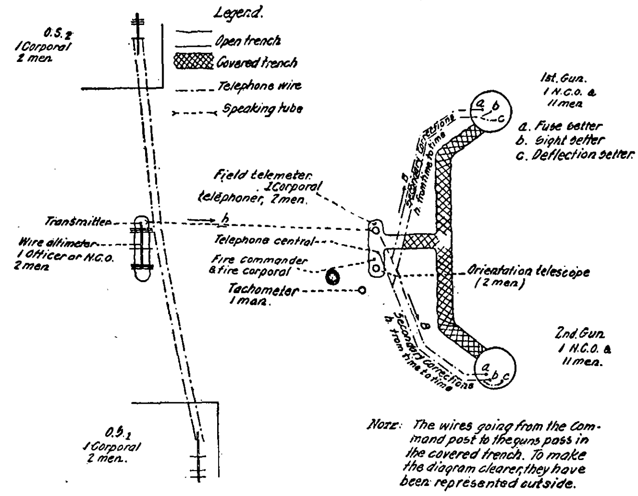
If lighting conditions do not permit a regular fire, use the mechanisms of fire mentioned in No. 75 of the Instruction on Fire (against a dirigible, progressive fire by 100 if it is coming, by 200 if it is going away). In this case a command of distance every 15 or 20 seconds is sufficient.

SPECIAL ASSIGNMENTS OF DUTY.

53. (*a*) *Lookout service.*—A permanent lookout service is established. It is assimilated to the guard service, and the

duties of the lookouts are as imperative as those of sentinels. At normal times two lookouts are enough. The officer second in command divides among them the zone to be watched. They go far enough away from the pieces so as not to be bothered by the noise but still keep within calling distance. They are equipped with good field glasses. They report every target in sight, observe it, and report the type of aircraft. They give the alarm only for enemy or doubtful airplanes and in case

54. DIAGRAM ILLUSTRATING THE LOCATION OF THE DIFFERENT APPARATUS OF A SEMI-STATIONARY PLATOON OF 2 GUNS.



of fire by a near-by post. They should be frequently relieved (generally every hour).

(b) *Allotment and trial of projectiles.*—The projectiles are divided among the chests by lots of fuses and charges. They should be tried in the loading position (incline the gun slightly, open the breech gently, and extract the cartridge with the rammer). If a cartridge does not enter, look for the reason; if necessary, file down rough surfaces. If a second trial is unsuccessful, reject the cartridge. Before putting the cartridges back in the chests, grease the bands. It is even better,

if enough personnel are available, to grease the bands during the fire.

(*c*) *Various precautions.*—Between periods of fire leave the muzzle cover and the breech cover in place but unbuckled; protect the laying apparatus, the fuse setters, and, in general, all the delicate parts of the matériel and of the auxiliary apparatus. Test the telephone connection with the distant posts every half hour. Establish a special assignment of duty for the periodical inspection of the telephone lines, even those which are working, and for the testing of lighting and signal apparatus, batteries, etc., as well as for maintenance work on the matériel.

55. DIVISION OF THE MATÉRIEL.

(Telephone and fire accessories.)

2 S. I. T. apparatus.
1 grounding plug.
4 coils.
1 wire altimeter, with screen.
1 24 cm. searchlight.
1 field glass, No. 8.

O.S. 2.

3 receivers.
3 ear pads.
1 field glass No. 8.

Second gun.

C. P., Altimeter and observation platoon.

1 switchboard and bell system.
2 apparatus with headpieces.
4 grounding plugs.
4 coils.
1 wire altimeter, with screens.
1 24 cm. searchlight.
1 field glass No. 8.
1 speaking tube.
1 wind tachometer.

C. P. Fire-conduct platoon.

1 field telemeter with automatic corrector.
2 S. I. T. apparatus.
1 orientation telescope with wind disk.
1 field glass No. 8.

Same as O. P. 2.

O. S. 1.

3 receivers.
3 ear pads.
1 field glass, No. 8.

First gun.

NOTE.—The telephone switchboard for outside communications is not shown in this plan.

CHAPTER III.

SCHOOL OF THE PLATOON.

"* * * They will use all their energy in overcoming all obstacles encountered."

56. The platoon consists of the commander's detachment and one or more guns.

DUTIES OF OFFICERS AND NONCOMMISSIONED OFFICERS DURING FIRE.

57. (*a*) *Commanding officer.*—Identifies the target and designates it to the guns and to the commander's detachment.

Estimates the speed and altitude if it has been impossible to measure them.

If he has a regulation telescope,[1] he generally repeats[2] the orientations which the telescope gives, corrects them if there is manifest error, anticipates them if the airplane begins to change direction.[3]

Gives the whistle signals for opening fire, suspending fire, continuing fire, and ceasing fire.

Orders the mechanism of fire to be used (fire by piece or comb fire).

Regulates the fire for deflection and for height.

Regulates it for altitude according to the reports made by the observers, whenever these reports are not directly laid off on the altimeter. (This latter process is obligatory with the wire altimeter.)

The commanding officer is sole master of the ship. He maintains the strictest discipline; he requires each man to give his entire attention to his own work, without being distracted by desire to see the fire.

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[1] In the contrary case he entrusts the determination and the direct report to the orientation details, to the officer second in command, or to an especially skilled noncommissioned officer.

[2] Or he can make the telescope operator responsible for checking, repeating, and giving directly the orientations which the operator reports in a low voice.

[3] In case the airplane keeps a straight line on the contrary, he is very careful not to anticipate the orientations. The α_0, which appears in the formulæ of the Instruction on Fire, is the present, not the future, orientation.

58. (*b*) *Officer or N. C. O. assisting the post commander.*—Has control of *all* the altimetry and observation services.

Has the target designated to the distant posts.

Designates the O. S. which will observe.

In case of need, he himself takes the post of altitude operator (wire altimeter), or of observer at the screen.

Provides for the transmission to the fire commander either of the corrected altitude, or of the corrections of altitude.

Sometimes his functions may be taken over by an N. C. O., in case he has been sent to the distant post or put in charge of the orientation.

59. (*c*) *Chiefs of detachments and sections.*—The chief of the commander's detachment assists, and, in case of need, takes the place of the officer or N. C. O. assisting the fire commander. He is generally employed as observer at the C. P. screen.

The chiefs of the gun sections are responsible for the work of their guns.

They transmit or repeat the whistle or verbal commands (generally by speaking tube).

They verify the proper transmission of the commands by telephone.

They put in verbal transmitters in case the telephone is not working.

They supervise the proper execution of the fire.

They supervise the recoil of the gun.

They provide for replacements in case of need.

In case of a lack of personnel, they take the post of elevation cannoneer.

CONDUCT AND EXECUTION OF THE FIRE.

60. (*a*) *General principles.*—Fire is conducted on the principles given by the Instruction on Fire.

As shown in this instruction, the principal elements to know, beside the corrector for the day, are five in number:

Altitude.
Orientation.
Actual speed (or angle of route and true speed or angular speeds in direction and in height).
Wind.
Ballistic error of altitude.

The ideal fire is when the first three elements are *measured continuously* during the whole fire and the last two are known by reports or have been determined before the fire.

Chapter V of the above-quoted instruction shows that adjustment is often difficult and sometimes even impossible; that it yields its first effect only at the end of a time considerably longer than the time of flight of the projectile—that is to say, sometimes as long as the duration of fire itself; and that the interpretation to be made of what is seen[1] becomes more delicate in proportion as the number of unmeasured elements becomes greater.

The commanding officers of units must therefore use every effort to insure *continuous* measurement of the elements of fire, and especially of the altitude. After each fire they will hold a critique of everything which was done, both by *themselves* and by their subordinates; they will minutely investigate the causes which may have prevented measurements, and give all their energy to overcoming all obstacles encountered. The only excuses to be accepted for the failure of altimetry are: (1) A cloud preventing the observation post from seeing; (2) airplane hardly visible and at the *opposite* side from the observation post; (3) telephone lines cut during the fire, in spite of the precautions taken to protect them. The fact that the airplanes flew in squadrons is not an excuse. By carefully giving the airplanes numbers with reference to a wire parallel to the base an understanding can be reached.

In case it has been impossible during fire to interpret the errors observed, an interpretation made quietly after the fire will often make it possible to approximate more closely, for purposes of later fire, certain estimated elements, and especially the speed.

61. (*b*) *Commands for execution of fire.*—As in the school of the gun.

62. (*c*) *Trial fire.*—It is in the province of the chief of artillery of the corps to specify what units are authorized to fire trial rounds and in what directions.

As has been mentioned above, if the wind and the ballistic error are not known by reports or measurements before the

[1] Failing a proper interpretation, there is danger of "deranging" the fire instead of adjusting it. It may be remarked that, so far as concerns observation for range, every successful *bracket* gives the error in altitude without difficulty of interpretation.

fire, they can be obtained, even under the best conditions,[1] only while fire is being adjusted, which often means too late. The first 30 or 40 seconds of fire, the only ones which may produce a surprise effect, will be sacrificed.

Hence the importance of trial fire. (See Nos. 37 to 46 of the Instruction on Fire.)

In view of the rapidity with which it must be possible to use it, it is necessary that the men be trained to execute their fire in as reflex a manner as the other drills.

63. *First case, airplane in sight but out of range.*—The round fired should immobilize the gun during only a few instants. Its only purpose is to give the wind.[2]

Commands:

"Such and such gun."
"A trial round."
"220" (meaning deflection 220) or "Such and such deflection."
"Angle 44° 45′." (The angle to be given the gun, read on the table in No. 46 of the Instruction on Fire.)
"5,000" (meaning range 5,000).
"Fire."

The gun.—Use the graduation on the runway and the 88-model level to give the gun the desired position. Set the fuse of a 22/31 shell (unless otherwise ordered) at 5,000. Load. Fire at the command "fire."

The fire is directed by a cannoneer designated by the chief of section. The chief of section does not lose sight of the airplane, and has the gun laid on it as soon as the round is fired.

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[1] Fire which can easily be interpreted, so far as principally concerns the part played by errors due to wind and to errors due to the speed. (See Chap. V of the Instruction on Fire.)

[2] The airplane being in sight, the altimeter operators generally have the duty of finding it, watching it, and keeping it in sight. They are not usually available for the altimetry of the round. But this rule is not absolute, and the section commanders have entire latitude to deviate from it, especially when the airplane is already under fire from another unit. (No. 78 of the Instruction on Fire.) For the rest, the ballistic error varies more slowly and within limits less serious than the wind. In an extreme case its value may be estimated on the basis of previous fire, on the wind, and on the temperature and the atmospheric pressure. (The work of the Gavre commission will shortly make it possible to be more definite on this subject.)

Commander's detachment.—The wind gauger determines the wind and arranges his disk in accordance with No. 36 of this present instruction.

NOTE.—No trial round for the wind is fired when the information given by the Aeronautic Service by previous fire or by nearby units seems to be sufficiently approximate. This information has the advantage of applying to several altitudes. The wind gauger should always have a copy of it. (See No. 36.)

When the wind gauger has no information about the wind, and when there is no time to fire a trial round, the wind gauger, to estimate the first round, uses the real fire, applying No. 39, 2*d*, of the Instruction on Fire. In accordance with this paragraph, he approaches the commander and gives, in an ordinary tone of voice, the corrections deduced from his measurements and from the inspection of his disk. This officer pays no attention to it if his fire is adjusted, but otherwise he gives the guns the corrections.

The wind gauger must, in all cases, observe the third paragraph of the same number, which prescribes that advantage be taken of one of the last rounds fired to measure the wind for a later fire. He takes note of all the measurements made in specifying the altitude. The platoon commander *is obliged* to communicate them to the nearby units.

64. *Second case; the regularity of the coming of the airplanes justifies a preliminary trial round, but no airplane being in sight, it is possible to take one's time.*—Follow No. 40 of the Instruction on Fire.

65. (*d*) *Designation of the target.*—As in the school of the gun.

66. (*e*) *Opening of fire.*—As soon as the target is designated, the layers follow it. The fire commander reports the speed and the altitude. As soon as he reports the orientation, drill without cartridge is executed, as described in the school of the piece. Fire is opened at the signal "Commence firing," preceded, if necessary, by the words "such gun."

67. (*f*) *Examples of mechanisms of fire to be used.*—See No. 77 of the Instruction on Fire.

First case: The altimeter works at the moment of opening fire and during the whole duration of fire.—Altimeter operators on an airplane must not lose it.

(*a*) Isolated airplane not under fire—ranging presumed easy.

Fire by piece, during the first four or five rounds, to facilitate observation; then use comb fire without pause.

If the fire is prolonged, resume from time to time (every minute, for example), fire by piece, with a single gun if need be, to facilitate observation.

(*b*) Airplane not isolated or already under fire—ranging presumed difficult or impossible. Use comb fire from the first.

Second case: Interruption of the working of the altimeter during the course of the fire.—The fire commander should be notified by the words "altimeter out of order" given by the chief of the altimetry platoon.

If the observation is still working (by visual signals, for example), keep the altitude constantly corrected by continuity of ranging (No. 65 of the Inustruction on Fire).

If the altimeter does not work, allow by estimation for the variations of the altitude of the airplane (see Third case).

Third case: Fire opened on an altitude which is estimated or measured by means insufficiently precise.—See No. 60, footnote, for the only excuses which can be accepted for the failure of the altimeter to work.

Fire seven or eight rounds by piece with a single gun.

Wait for a report and reflect on what you have seen. As soon as this report has arrived, whether it be a report of altitude, "measured altitude so much" or of error in altitude "short (or over) so much," proceed with comb fire.

If the chief of the platoon reports "not observed," base estimations on some indices (bursts hiding or hidden by the target; with the method of "estimated speed," rounds in front presumed short, rounds behind, presumed over). Fire a series of comb fire volleys, changing the altitude whenever the airplane shows that the bursts are way off in direction and in site.

Note.—In all cases, when the airplane dives squarely, suspend fire.

When ammunition is limited, proceed by volleys of 10 rounds each, signaled by whistle at the moment when the airplane seems about to keep a regular course.

CASE OF DEFICIENCY IN PERSONNEL.

68. The principle governing the replacement of men who are missing is the following:

It is better to fire with only one gun than to sacrifice the altimetry and the observation. (See No. 26.)

The altimetry posts must always be kept complete. The altimeter operators can be taken from their apparatus only in case the telephone connection breaks down. In that case, they may be used as signalers and assistant observers.

FIRE AT LOW ALTITUDES.

69. This fire must be made the object of very frequent drills; it is the only way to avoid laxity in executing it in case of real fire.

Goniographs and sitogoniographs.—They are not generally graduated lower than 1,500. The *goniograph* needs no special attention, since the influence of the altitude on the correction for deflection is slight.

For the *sitogoniograph*, remember that the correction for site is almost proportional to the altitude. Therefore: Between 700 and 1,500, double the altitude, and estimate corrections which are one-half of those which correspond to the curves of orientation, placing the reading index at the middle of the interval which separates the curve of orientation commanded from the curve marked 90. Below 700, if the absolute value of the orientation is between 60 and 90, lay off a zero correction for site; otherwise lay off the correction +10 if the airplane is coming and —10 if it is going away.

Conduct of fire.—(1) Altitude included between 1,000 and 1,500. In comb fire diminish by half the jumps in altitude, as in No. 33.

(2) Altitude below 1,000. (The altitude telemeter is not graduated below 1,000.)

The fire commander.—The fire commander gives the order "Fire on horizontal ranges at my command," [1] and estimates, or causes to be estimated, the orientations by eye (the telescope no longer gives good observation).

As soon as a range is reported to him by the operator of the altitude telemeter (see below), he subtracts 200 meters from it, and commands fire by fours or progressive fire, according to No. 75 of the Instruction on Fire. If no range is reported to

[1] Speaking more generally, the order "at my command" is to be given whenever the fire commander wishes to regulate himself the ranges or the fire by series—by 4, progressive by 100, 200, 300, 400—(see footnote of No. 52).

him, he estimates the actual range by eye[1] and reports it to the telemeter operator, who sends back to him the corrected range (or he estimates directly by eye the corrected range), subtracts 400 meters from it, and commands a progressive fire by 100, 200, 300, or 400, adding 100 meters to the jumps prescribed by No. 75.

Telescope operators.—They become available for estimating the orientation, if the fire commander judges that they are capable of it.

Operators of the field telemeter (or of the 1915 model horizontal distance telemeter).—Determined regularly the horizontal range to the target, using the azimuths sent by the O. S.[2] From this the setter deduces the future fuse-setter range with the aid of the table of corrections for range at low altitudes (Annex IV) which he must always have with him.

Altimeter operators of the command post.—They extend the telephone line up to the field telemeter, or, failing that, they transmit the azimuths sent by the observation post.

Altimeter operators of the observation station.—They go to the distant post of the field telemeter,[3] determine the azimuths of the airplane, and send them to the command post by telephone.

Adjustment of fire.—Fire, if possible, two trial rounds before the fire. Measure their horizontal ranges and correct the base of the horizontal-range telemeter to correspond.

In view of the great number of causes which may produce errors in range, it is very difficult to adjust the base during the fire itself. If the range is not the result of a measurement, the adjustment for range is impossible.

The guns.—In fire by 4, the fuse setter successively sets 4 cartridges at the same range. In progressive fire, he sets 4 cartridges successively, the first for the range commanded, the three others with range increased by 100, 200, 300, or 400 meters.

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[1] If he has a Barr and Stroud, he has the range measured with the Barr and Stroud.

[2] When this telemeter is equipped with a parallax circle and with a slide rule, the horizontal range is read on the altitude rule opposite site 45°.

[3] Or they use the distant post of the altimeter as an azimuth circle, by locking the telescope stationary on its axis and by loosening the set screw of the horizontal graduated circle. It must be set up so that the 320 mark corresponds to the direction of the command post.

FIRE ON ALTITUDES INCLUDED BETWEEN 4,000 AND 5,000.

70. *Goniographs and sitogoniographs.*—They are not graduated beyond 4,000. For the *goniograph,* set the altitude at 4,000 and pay no attention to the error in altitude, which has no great importance. For the *sitogoniograph,* invert the graduations of the altitude and the speed. For example, if the altitude is 4,500 and the speed is 38, lay off on the sitogoniograph: Altitude, 3,800; and speed, 45.

Altitude telemeter.—Is not graduated beyond 4,000. Divide the altitude by 2. Double the distances read. For precise fire, allow for the fact that the fuse-setter range is not proportional to the altitude, and that it follows this pracical rule: For a range read in the neighborhood of 3,500, give the ballistic slide a correction of +50. For a range read of 3,000, give a correction of —50. For a range read of 2,500, give a correction of —100.

FIRE BY SOUND.

71. When sound clearly indicates the proximity of an invisible target, we may fire by sound.[1] The rules for this fire against dirigibles are entirely different from those against airplanes.

(*a*) *Dirigibles.*—If tracer shells are available, in view of the great dimensions of the target and the effectiveness of the projectile, the chances of obtaining a result do not appear negligible. In view also of the value which is set on the destruction of such a target, post commanders should not hesitate to open fire under unfavorable conditions, and to fire, if the target remains long in good range, as many projectiles as in the case of a visible airplane.

To reduce the element of chance as much as possible, observe the following rules:

(1) Try to determine approximately the direction and, if possible, the site of the target with the aid of listening apparatus (interfering apparatus or apparatus for listening with both

[1] The decision to fire can not be taken by the post commander until after he hears by ear with no apparatus. The listening apparatus may report the direction of the sound but not its nature, for there is always danger of their modifying its timbre and intensity.

When the post commander is thus sure of the presence of an aircraft, and knows whether he is dealing with an airplane or a dirigible, he bears in mind, in reaching a decision, information which he may have of the movements of friendly aircraft and the special orders which he has received.

ears; with the latter the movement of the target is more easily followed). Whatever apparatus may be available, good results can be obtained only if there is not too much noise in the neighborhood, and with an observer who has been carefully instructed. Experiments made by day with an airplane, the observer having a bandage over his eyes, will make it possible to note the precision obtained. Remember that direction given by sound can not be obtained as rapidly as direction given by view.

(2) By following the target for 10 seconds, find the direction of his movement (coming or going, moving toward the right or toward the left).

Based on the report made by the observer and the azimuth read on the listening instrument, the fire commander decides the azimuth to be adopted, for the first 6 rounds of each gun, by applying the following rule:

To allow for the movement of the target during the time the sound is traveling, the time lost in laying (calculated up to the middle of the fire) and the time of flight, he makes corrections, in the proper direction of the azimuth read on the apparatus, of 25, if the observer reports a cross movement and the range seems to remain constant, or of 15, if the observer reports at the same time a cross movement and a variation in site.

These figures assume that the azimuths are graduated from 0 to 640, each unit therefore being equivalent to 10 mils. The figures are good for low sites, and must be increased one-half for 45° site, and doubled for 60° site.

For two-gun posts, the first gun adds 5 to the azimuth given, the second subtracts 5 (take 10 instead of 5 if experience has shown that a high degree of precision can not be expected of the apparatus and the observer available).

(3) The fire commander usually gives the range 3,000 if the dirigible is flying almost directly over the post (site of more than 45° indicated by the apparatus), 5,000 if the sound gives the impression that the target is near but not flying over the post (the site in that case should be between 25° and 50°), 7,000 if the target is heard without apparatus but sounds as if it were distant (site between 15° and 30°).

Do not forget that the indications deduced from the site depend on the altitude, and that the latter will generally be lower for a dirigible coming toward us than for a dirigible returning lightened of the explosives which it carried (probable altitudes

2,000 to 2,500 for objective coming, 2,500 to 3,000 or even more for objective going away).

As far as possible, an effort should be made to locate the target precisely by means of reports of the distant observer. Whether or not he has a listening apparatus, ask him for the approximate azimuth of the target, and from it, with the aid of the telemetry apparatus, deduce the range.[1]

In any case, give the range in multiples of 1,000 meters. In view of the nature of the projectile, it is of no use to attempt greater precision, as it would merely prove illusory.

(4) The inclination of the gun is sent to the guns in the form " So many degrees, increase by 3." The command is given by the noncommissioned officer, who is normally the operator of the altitude telemeter. He obtains the number of degrees by adding to the site indicated by the listening apparatus the quantity given by the following table:

Distance	3,000	5,000	7,000
Orientation:			
Coming	15°	10°	20°
Transverse movement	0°	5°	15°
Going	15°	0°	10°

(5) When the elements of fire are reported to the guns the fire commander gives the signal for opening fire by a blast on the whistle. At this signal, or even as soon as he has given the reports expected of him, the observer at the listening apparatus takes his ears away from the apparatus (otherwise he would be deafened or even wounded by the discharge of the guns), and the fire commences.

[1] Only a rough indication is possible. No attention must therefore be paid to the fact that the sound does not take the same time to reach the O. S. and the C. P. But it is possible, after a first measurement made in this way, to estimate whether the target is nearer to the C. P. or to the O. S. For example, if it is estimated that the distance from the target to the O. S. is 2 kilometers less than that to the C. P., call the signal " top " twice at intervals of six seconds; at the first signal, read the azimuth at the O. S. and pay no attention to that of the C. P. until the moment of the second " top."

If the dirigible is considerably in the direction of the O. S., deduce merely from the azimuth received whether the dirigible is flying over the O. S., or whether it seems to him to be on the side toward the C. P. or on the opposite side.

At the end of the fire the fire commander commands "Suspend firing," by two short blasts of the whistle. Not another round must be fired on any pretext; cartridges on which the fuse has been set and which by an accident of the fire were not discharged are kept for the next fire (as the fuses need not be set precisely, they will serve).

When ordered to do so the observer again commences to observe, as for the first fire. The comparison of the azimuths and the sites obtained with those of the first fire enables him to verify his estimate of the direction flight of the target. A second fire proceeds under the same conditions as the first, and so on.

Remark I: The means of defense of the dirigible against this fire consist in stopping its motors and rising rapidly by throwing out ballast. If the noise of a dirigible which has been clearly heard suddenly stops, it may therefore be supposed that it has stopped its motor and is now a little in front of its last ascertained position, but considerably higher (at least 500 meters). A new fire may then be tried, almost in the same direction as the preceding, and with the inclination of the gun raised 5°. After this fire, another is commenced only if the target has again been heard.

Remark II: As the preceding method has not been tried out, it is given as a suggestion, and with permission to modify it. In particular, in view of the necessity of marking a time of suspension between two fires and of increasing the average rapidity of fire, we may be led to fire by eight rounds per gun, "increasing by 2."

(*b*) *Airplanes.*—In view of the poor results obtained in fire by daylight against airplanes, almost no success can be expected in fire by sound. At most, a moral effect may be hoped for. It is in the province of the commander of anti-aircraft defense to indicate in what cases fire by sound is justifiable.

4069°—17——10

EXAMPLES OF FIRE.

FIRST EXAMPLE OF FIRE.

72. Wind assumed to be known. Isolated airplane. Method of estimated speed. Wire altimeter.

Phases of the fire.	Telescope operator.	Chief of platoon.	Chief of altimeter and observation platoon.	Wind gauger.	Fire-conduct telemeter.	Fuse setter.	Pointer.
1. Designation of target		Airplane 310, 25°	At O. P.; airplane forward 25; 230.				Go.
2. First taking of altitude.			Measured altitude, 3,100.				
		Altitude, 3,100		Deflection+20.	Set altitude at 3.100; slide at+100.		
	Speed+50	Speed, 32					
		Altitude+100 [1]		Drum 90			
3. Commencement of drill without cartridge.	S+45	Speed+45			66		
			Altitude, 3,200		64		
4. Opening of fire, 3 salvos by piece, then "comb fire."		Whistle blast			Altitude, 3,200.		
					65		
	S+30	Speed+30; comb fire		Deflection+10.	65		
					64	6,500	Ready.
					63	6,500	Do.
					62	6,400	Do.
5. Observation adjustment.			Slightly short		61	6,300	Do.
		Add 10		Deflection+20.	60	6,200	
			Corrected altitude, 3,400.		Altitude, 3,400.	6,100	
					65		
A very good shot, airplane dives.		2 short blasts on whistle (suspend firing).			65	6,100	
			Altitude, 2,800		65	6,100	
Airplane rights itself, but still dives slightly.	Site+30	Site+30; 1 whistle			65	6,100	
		Altitude, 100; accelerate 5	Altitude, 2,600	Drum 100			

Airplane rights itself entirely.		Altitude+100; normal speed.				
	Site+30	Site+15			Out of range	
	S+15	Site+15		Measurement of wind.		
6. Cease firing						
7. Measurement of wind at the altitude of the last rounds.		To nearby posts; wind measurement; altitude, 2,600; velocity, 12 miles; direction, 25 (250 grades from north).				

[1] Ballistic error shown by previous fire.

SECOND EXAMPLE OF FIRE.

(For the transmission of the commands, see first example.)

Enemy squadron at 10 kilometers, approaching slowly. Wind unknown. Estimated speed.

Phases and incidents of fire.	Elapsed time in seconds.	Orientation telescope.	Lieutenant, chief of platoon.	Chief of altimeter and observation platoon.	Wind gauger.
			Alarm:		
Designation of the target and trial fire.	0		First gun, trial round—220, 44° 45′, 5,000.		
			Second gun, airplane—220, 20°, the highest of a squadron of 5	To O. S.	Looks on the telescope and plugs direction 220 and site 20°. Places himself under tachometer.
				Forward—32, 145, No. 2 on 5.	
	16		First gun, airplane—230, 21°, the highest of a squadron of 5.		
				Measured altitude, 2,500.	Burst of the round; wind measurement, etc.
	32		Speed 38		
			Altitude +200		
		S +30	S +30		
	100	S +15	S. O.° Comb fire		Initial correction of wind.
			Commence fire.		
	104			Altitude 2,400	Deflection —30, drum 110.
	108	S —15	S —15		
	112		S —30		
	116				
	120	S —30	S —45		
	124				
	128	S —45	S —45		
	132				

Irregular rounds	136	S −75			
No conclusion, in view of changes in orientation.	140		Site −90	Doubtful	Deflection +20.
	144	Site −90			
				Altitude, 2,300	
Irregular rounds	148				
	152				
1 good round		Site −75	Site −75		
Airplane dives slightly			Lieutenant anticipates measurement by command; true altitude, −100, accelerate 5	Altitude 2,100	
Irregular rounds					
Airplane dives steeply, going away.			{Suspend firing {Normal speed		
Airplane continues to dive, going away.			Change of target the highest of the 4—140, 45°; altitude, 2,800, S +15.	O. S. Change of target forward 30.	Deflection +20.
				No. $\frac{1}{4}$,[1] 230	Drum 100.
		Not seen	First gun, commence firing		
		Seen	Altitude 3,400; S −30; comb fire.	Altitude, 3,400	
		S +30			
Cease firing			To the near-by posts		Wind measurement.
Wind measurement			Wind, etc		

[1] No. 2 with reference to the wire parallel to the base. Numbered from the top down.

Appendix I.

"Give me a good adjustment of the instrument and I will give you good altimetry."

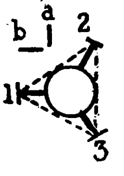
ARTICLE 1.

Setting up the 1916 Model Altimeter and the 1915 Model Field Telemeter.

The precision to be sought is given in Nos. 19 and 20 of the Instruction on Fire. The setting up of the instrument comprises two operations, namely, (1) orienting the "central post" and the "distant post"; (2) measuring and laying off the base, and, if necessary, the difference in altitude.

TO ORIENT ONE OF THE POSTS.

1. Place the tripod on firm ground and, if possible, on three stakes planted in the ground, making the three vertices of an equilateral triangle.



Adjust the length of the feet so that the whole apparatus is at a good height and nearly plumb.

Insure as far as possible the verticality of its general axis of rotation by adjusting the set screws while watching the spherical level or (better) the two right-angle levels which are found on all the recent models.

Set one of the two levels *a* and *b*, say level *a*, parallel to the side 2–3 of the triangle 1–2–3 formed by the three set screws. Turn first 1 and then, by almost equal turns, 2 and 3, so that the bubble of *b* will stand between its limit marks (the bubble moves in the same direction as the screw which corresponds to it). Then turn 2 and 3 equally, but in opposite directions, until the bubble of *a* stands between its limit marks. See that the bubble of *b* has not moved.

Slightly loosen one of the set screws so that the whole "post" can rotate about its vertical axis.

When this has been done, the processes to be used for orienting depend on circumstances.

First case: The two posts are in sight of each other.

(*a*) *Altimeter.*—Make the telescope stationary and parallel to the vertical graduated limb by means of its key.

Set the horizontal graduated plate at zero (C. P.) or at 320 (O. S.) and lock it in position by means of its adjusting screw.

Turn the whole apparatus so that the arrow on the vertical limb, and then the telescope itself, point at the other post.

Tighten the set screw gently, and see that this tightening has not disturbed either the verticality or the orientation.

(*b*) *Field telemeter.*—Follow a similar procedure.

Second case: The two posts are not in sight of each other.

SETTING UP THE INSTRUMENT.

(*a*) *Altimeter.*—In the first place, when the declination of the place is not exactly known, it is determined by sighting from

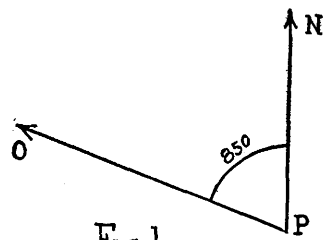


Fig. 1.

a known point to a known point. By setting the two instruments side by side and *not near any metallic body*, make sure that their two compasses correspond, or, if they do not, determine the declination of each of them.

When this has been done, locate as near as possible on the best available map the two posts P and O.

Measure on the map the angle which P–O makes with the true north, say 850 mils (fig. 1).

The horizontal graduated plate being set at zero (C. P.) or 320 (O. S.), being locked in that position by its adjusting screw, and one of the set screws being slightly loosened, turn the whole instrument so as to give it an approximate orientation.

Make sure that the compass has been adjusted in the desired direction (counter-clockwise) and, with reference to its zero, by an angle equal to the declination of the place.

Loosen the adjusting screw of the horizontal plate and turn it 850 mils in the desired direction with reference to its reference index. Tighten the adjusting screw.

Turn the whole instrument until the magnetic needle is exactly on its reference mark. Tighten the set screw. Make sure that the verticality of the whole instrument has been kept true and correct it if it has not. Verify the orientation again.

Loosen the adjusting screw and set the horizontal plate again at zero (or 320). Tighten the adjusting screw.

(*b*) *Field telemeter.*—Follow a similar procedure. Do not use the compass of the central post until the whole movable part has been taken off and taken away (this precaution will not be mentioned again).

SETTING UP ACCURATELY.

(*a*) *Altimeter.*—Setting up the instrument by compass is almost sufficient for the altimeter, even if the position of the posts on the map is not very exactly known.

It is necessary, however, to verify it as soon as possible by simultaneous sighting (process of the signal "top") on a star of rather low angle of site, on the moon, or on the sun (to sight on the sun, put a photographic plate between the eye and the eyepiece).

For this purpose, always set the telescope parallel to the vertical limb and pin it, release the horizontal limb by loosening its adjusting screw and turn it to sight on the star. At the signal "top," the same graduation should be read on both limbs. (The "top" need not assure simultaneity closer than within 20 seconds. Simultaneity is unimportant if the star chosen is the North Star.) If the O. S. reports 230 and the C. P. reads 228.5, it is deduced that the parallelism is assured when the horizontal plate of the C. P. reads 15 mils less than that of the O. S. Therefore, set the horizontal plate of the C. P. again at 320 (it then points in the direction of the C. P.) and that of the O. S. at 640—1.5, or 638.5.

When the setting-up has been verified, set stakes to mark the direction of the opposite post, so that the orientation to be given the instruments can quickly be verified or refound.

(*b*) *Field telemeter—Verification of the parallelism by simultaneous sighting on a star.*—(1) Central post not equipped with the parallax circle.

At the central post, set the instrument in the true vertical, and with the index opposite its reference mark. Choose a star with a low angle of site and a few mils to the left of this direction. Designate it to the distant post (by its site) and give the signal "top" when it arrives on the line of sight of the instrument.

At the distant post, the instrument being in the true vertical, the zero of the graduated limb being opposite the reference mark, and a screw being slightly loosened so that the whole instrument can rotate, lay for direction on the star by moving the whole instrument, and stop at the signal "top."

(2) Central post equipped with the parallax circle. The operation is the same, but any direction may be chosen. The index being opposite zero of the parallax circle, define this direction by the division of the circle which is opposite the reference line. This division, and not the zero, must then be laid off at the distant post.

Joint orientation of the two posts.—(*a*) Central post not equipped with the parallax circle.

Stake out the direction of sighting of the central post, the index being opposite its reference mark.

At the O. P., take advantage of a moment when a French airplane, at a low altitude and preferably not far away,[1] passes in the direction of "zero" to send the C. P. the signal "attention, top."

At the C. P., lay on the airplane, and stop at the signal "top." Stake out the direction of sighting obtained.

From the separation of the two stakes and from their distance deduce the angle η between the two directions staked out.

By turning the two posts by the angle η, the adjustment of the instruments will be bettered. Repetition of this process will give practically perfect precision.

To reach the goal more quickly, note that the value of the angle by which the two instruments must be turned to reach a perfect position is

$$\epsilon=\eta\left(1+\frac{Oa}{OP}\right)$$

Oa being the horizontal range of the airplane.

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[1] If the operation can be repeated several times, it is better to have the airplane 3 or 4 kilometers away.

The chief of the O. S. estimates this distance (when in doubt it is better to take too low a figure), and sends it to the C. P., where the officer in charge of the operation calculates ϵ.

At the C. P., move the second stake, setting it farther away from the first in the same direction, so as to get two sighting directions different from ϵ. Set up the instrument by "direct sighting" on the stake thus placed.

Send the O. S. the value of ϵ and the direction of the movement to be made (say: turn 25 mils to the right).

At the O. S., set the horizontal limb at 320, turn it 25 toward the right, stake out the direction thus obtained, set the limb again at 320 and turn the whole instrument so as to bring it back on the stake.

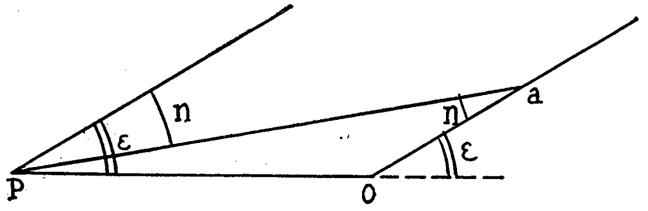


Fig. 2.

(*b*) *Post equipped with a parallax circle.*—Use the same method. It is not necessary to employ stakes to determine η, as the value of η is read on the circle.

Turn the central post by the angle ϵ, using the process which has just been described for the different posts.

NOTE.—Persistent bad weather may sometimes make it impossible to verify the parallelism. In that case, the following method may be used.

Let Px_0 and Oy_1 be the original directions of the "central post" and of the "distant post." The distant post, by the signal "top," reports that an airplane is passing at α_1 on Ox_1. The central post makes its new original direction Px_2 pass through this point. It then waits until an airplane passes at α_2 on this direction, and in its turn signals its passage to the O. P., which makes its direction 320 pass through this point. And so on, using airplanes which cut the prolongation of the base, alternatively on one side and the other, until the movements to be made each time become practically negligible. It is necessary each time to verify the verticality of the axes.

TO MEASURE AND LAY OFF THE BASE.

2. The base must be known correct to within 1/100 (30 meters for 3,000 meters), or at least within 1/50.

The map gives a first idea of it, but the measurement on the map is sufficient only if the position of the posts has been put down true to within a score of meters. Otherwise, it will be necessary to verify the measurement by one of the following processes:

First case.—There is available a Barr and Stroud, or a battery telescope having a micrometer division in mils.

If the terrain allows, the base is divided into a series of sections, the ends of which are mutually in sight of one another. Each section is measured, either by the Barr and Stroud[1] or by the stadimetric process described below.

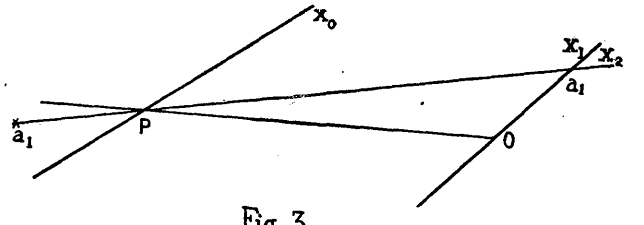


Fig. 3

Stadimetric process.—Let $P\ O$ be the section to be measured (fig. 4). At P set up a battery telescope. Establish at O, with the aid of two stakes, a base $J1$, $J2$, approximately perpendicular to $P\ O$, and with a length d at least equal to 1/40 of the length $P\ O$ (say, for example, 100 meters per 3,000 meters). Measure with a 10-meter tape. With the micrometer of the telescope, measure *to within 1/4 mil* the angle $J2$–P–$J1$.

The distance $P\ O$ is given by the formula:

$$P\ O = \frac{d}{\epsilon}.$$

Second case.—There is no time to get the necessary instruments and use them as above.

Fire two trial rounds in the probable direction of fire, and follow No. 43 of the Instruction on Fire.

[1] Even when P and O are in sight of each other, the precision is doubled if the base is divided into two almost equal sectors which are measured successively.

Article II.

ADJUSTMENT OF "THE BATTERY POST OF THE FIELD TELEMETER."

PRECISE SETTING-UP OF THE INSTRUMENT IN THE CASE OF PROLONGED OCCUPATION OF THE POSITION.

By applying No. 29 of the Instruction on Fire (par. *a*), the maladjustment of the line of sight and the deviation from the vertical of the axis of the telemeter can be determined and corrected in the following way:

(*a*) *Preliminary operation.*—Take a precise measurement of the site of three points of reference *X*, *X'*, and *Y*, situated ap-

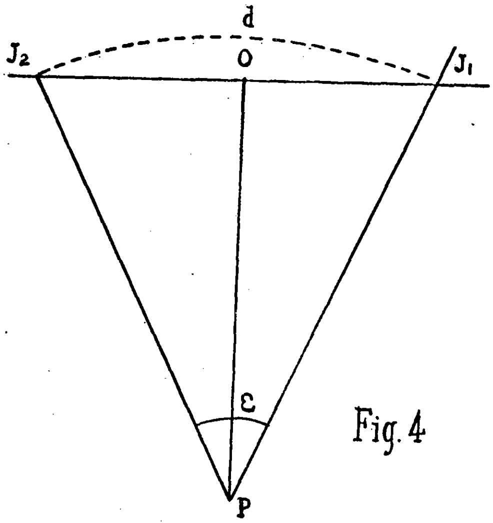


Fig. 4

proximately opposite and at right angles to one another (fig. 5). Borrow the battery telescope from a field battery. To measure the site of *X* take the following four measurements: A first measurement in the usual way, i. e., with the micrometric scale set vertically; a second measurement with the telescope turned 180° about its geometric axis; then turn the telescope end for end in its socket, point it again toward the point *X*, and take two new measurements as above.

Take the the mean of the four measurements taken.

Do the same for X' and Y.

(*b*) *To adjust the telemeter* (line of zeros, vertically).—Let s and s' be the sites obtained for X and X' with the battery telescope.

Measure the sites of X and X' by the altitude telemeter, taking for each the mean of several operations.

Let σ and σ' be the sites obtained (sites read in degrees and fractions of degree, then converted into mils, 1° equaling 17.7 mils).

Let ϵ be the error in adjustment of the telemeter telescope (maladjustment of the line of sight), a positive number if it is inclined up with reference to the distances quadrant.

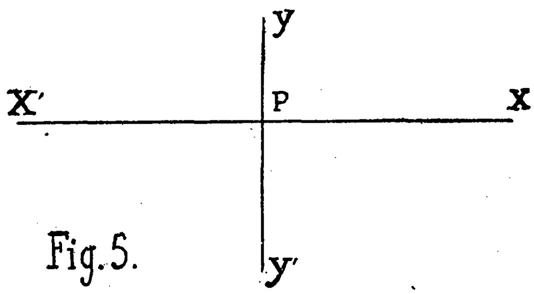


Fig. 5.

Let η be the deviation from the vertical of the axis, a positive number if the axis inclines toward the side of X'.

ϵ and η are given by the formalæ:

$$\epsilon = \frac{s+s'}{2} - \frac{\sigma+\sigma'}{2}$$
$$\eta = \frac{s-s'}{2} - \frac{\sigma-\sigma'}{2}$$

formulæ which must be applied roughly, taking s and s', σ and σ' with their signs.

If ϵ and η are less than 5 mils, consider the adjustment sufficiently precise.

If, on the contrary, $\epsilon = 12$ mils and $\eta = -8$ mils, ϵ being positive, the telescope must be lowered 12 mils.

The telescope is set in a socket, the position of which is regulated by a trigger set in between two set screws. To shift it the desired amount choose two distant points situated in the

same vertical plane and at 12 mils apart. Lay the instrument on the higher point, and mark its site very exactly on the telemeter. Loosen the set screw from below (from above if ϵ is nevative) several turns and tighten the upper screw equally, but without forcing it too much. See how far the telescope has been lowered by taking the telemeter reading of the same angle of site as before. Repeat the operation from the beginning until the error has been corrected.

The error ϵ being corrected, to correct the error η it is sufficient to read the angle s on the telemeter, and to lay the instrument on X by adjusting the set screws of the tripod. Verify that the site of X' is exactly equal to s'. Lay off on the telemeter the site of Y, and lay the instrument on Y with the set screws of the tripod. By sighting on X, verify that the verticality in the direction X X' has not been disturbed, etc. The verticality thus obtained is much more precise than that given by the spherical level.

Appendix II.

WIRE ALTIMETER.

Dimensions.—See diameter 1.

The value indicated for the product ab (notes to the Regulations), i. e., ab=100, applies to bases of about 3,000 meters. For bases of about 4,000 meters take ab=1,200.

Setting up the instrument.—The altimeter should be set up to secure—

(1) By rough approximation, the orientation of the two rules parallel to the base.

(2) With the greatest possible precision, the horizontality of the rules, the horizontality and parallelism of the wires, the height of the wires above the sight slits, and the perpendicularity of the wire with reference to the proper point on the scale.

Commence by putting in place the two horizontal rules. To orient them use one of the posts of the field telemeter (or of the 1916 model altimeter), the compass of which is sufficiently precise.

The horizontality of the rule to within 2 or 3 mils will be secured by passing an 88-model level along its whole length.

Next put in place the four stakes and the two crosspieces between which the wires must be stretched. These crosspieces must be leveled very carefully. For this purpose use the 4-meter rule used in setting up the runways of platforms and the 88-model level. It is also possible to sight on the horizon at the point of zero site.

A first setting up of the wires may be made with the aid of the distant post of the field telemeter with which it is possible to set stakes perpendicular to the base. (See Appendix I.)

This setting up will be corrected by the very precise method which is based on the observation of the passage in the vertical plane of each of the wires of a star, of the moon or of the sun (the latter observed through a photographic plate). These vertical planes are defined by the wire itself and by a plumb wire suspended from it near one end.

At nightfall the observer at the lateral post waits until a star of less than 45° site (or one of the edges of the moon if this is possible under the circumstances) enters this plane. He signals the precise moment of this entry. At once the corresponding observation is taken at the battery post, and the position of the horizontal wire is corrected accordingly. When this operation is well executed it is possible to insure parallelism to within about 1 or 2 mils.

When there is any wind the plumb line oscillates; to obviate this put it in a vessel full of water, which promptly dampens the oscillations.

An altimeter set up with all the precautions listed above affords an exactitude equal to that afforded by most apparatus equipped with telescopes, and the latter are often hard to adjust and set up.

Case when the two posts are not at the same level.—If the difference of level does not exceed 1/100 of the base, pay no attention to it. Otherwise,[1] make the following modifications in the battery post and in its use:

(*a*) For the metric graduation drawn on one of the sides of the principal rule substitute a fan-shaped arrangement of straight lines, obtained in the following way (Diagram II):

---

[1] So far as possible avoid differences of level greater than 100 meters.

At the height of the lower part of the rider draw the same metric graduation as usual. At the height of the lower part of the rule, say about 6 cm. lower (dimensions given in Diagram I), draw a second graduation, the middle of which is immediately underneath the middle of the first graduation (vertical of the sighting wire), but the scale of which is reduced by $c/1000$ if the *O. S.* is higher than the *C. P.* and increased by $e/1000$ if the *O. S.* is lower than the *C. P.* Draw straight lines joining the corresponding points of the two graduations thus obtained, and give these lines the same numbers as those on the upper graduation.

(*b*) Prolong the index of the rider by a vertical beveled alidade which abuts against the graduated side of the rule. On this rule draw a graduation in $1/h$, the line $h=1000$, immediately underneath the lower graduation, the line 2000 at the middle of the interval between the two graduations, etc. (Diagram II.)

(*c*) *Use.*—The rider will be moved to bring the point of the rod which corresponds to the altitude to coincide with the line which corresponds to the number reported by the operator at the *O. S.* In the figure, the rider is placed for altitude of 2 kilometers (altitude in round figures), with the division 240 announced.

Appendix III.

DISKS GIVING THE WIND CORRECTION IN THE METHOD OF THE ACTUAL AIRPLANE SPEED.

Note.—The tables giving the corrections for wind in the tachometer method will be described in the Instructions accompanying the teletachometers, when they are issued to the platforms.

"To fire well, measure your wind, correct your wind."

The corrections for wind are given with a sufficient approximation by the following formulæ (notes to the Instruction on Fire):

Deflection difference: $Cd=2.2\times W\sin\varphi$

Site: $Cs=0.42\frac{h}{1000}W\cos\varphi$

They are read on a wind disk. (See No. 36.)

All posts which do not have either the regulation disk connected with the orientation telescope (or a similar disk), or a disk connected with the gun and which gives satisfactory service will set up the following apparatus (Diagrams III and IV).

Cut out a circular disk 40 cm. in diameter, and on it draw (1) At the circumference, a scale in mils running counterclockwise; (2) on a circle 30 cm. in diameter a scale, each line of which represents 10 degrees, running clockwise. The zero degree corresponds to the 480 mil mark.

Nail this wooden disk horizontally on the top of a strong stake planted in the ground, orienting the zero mil toward the west, which brings the zero grade toward the north.

Then cut from thin wood, from varnished cardboard or from zinc, a circle 30 cm. in diameter, on which will be drawn the graphical sketch of Diagram IV.

The sighting apparatus which is to be kept laid on the airplane will comprise (Diagram III) :—two right-angle alidades, each with a rider, pivoting about a nail driven through the center of the circle; the alidade of deflection, which is oriented according to azimuth of the airplane, and which carries a simple graduation in wind velocities; the site alidade, which carries a measuring apparatus for wind velocity; and the site rider, which has a division in altitude perpendicular to the alidade. The site alidade, which is oriented perpendicularly to the sighting plane, ends in the index for reading azimuths on the division in mils. These alidades will be made of wooden rules, 20 by 10 mm., nailed on a common center.

The deflection alidade is prolonged, on the other side of the center, by a small rule, to the end of which is hinged a second small rule, moving in the sighting plane in front of a gimbal mounting graduated in angles of site.

The apparatus thus constructed will be used (1) to locate an airplane in the sky, in site, and in azimuth; (2) to give the corrections for wind, as described in No. 36 of these present Regulations.

4069°—17——11

APPENDIX IV.

(See No. 69.)

Table of corrected ranges.

Low altitudes (500 m.) Speed=35 m. T/D=0.0049.

Horizontal distances.	Coming 0	15	30	45	60	Coming 75	90	Going 75	60	45	30	15	Going 0
2,000	19	19	20	20	21	21	22	23	24	25	26	26	26
2,200	21	21	21	22	23	23	24	25	26	27	28	29	29
2,400	23	23	23	24	24	25	26	28	29	30	30	31	31
2,600	24	24	25	25	26	27	28	30	31	32	33	33	33
2,800	26	26	26	27	28	29	30	32	33	34	35	36	36
3,000	28	28	28	29	30	31	32	34	35	36	37	38	38
3,200	29	29	30	31	32	33	34	36	37	39	40	40	40
3,400	31	31	32	32	34	35	36	38	39	41	42	43	43
3,600	32	33	33	34	35	36	38	40	42	43	44	45	45
3,800	34	34	35	36	37	38	40	42	44	45	47	47	47
4,000	36	36	37	37	39	40	42	44	46	47	49	49	50
4,200	37	38	38	39	41	42	44	46	48	50	51	52	52
4,400	39	39	40	41	42	44	46	48	50	52	53	54	55
4,600	41	41	42	43	44	46	48	50	52	54	56	57	57
4,800	43	43	43	45	46	48	50	52	55	57	58	59	60
5,000	44	44	45	46	48	50	52	55	57	59	61	62	62
5,200	46	46	47	48	50	52	54	57	59	61	63	64	65
5,400	48	48	49	50	52	54	56	59	61	64	66	67	67
5,600	49	50	51	52	54	56	59	61	64	66	68	69	69
5,800	51	51	52	54	56	58	61	63	66	68	70	71	72
6,000	53	53	54	56	58	60	63	66	68	71	73	74	74
6,200	55	55	56	57	59	62	65	68	71	73	75	76	77
6,400	56	57	58	59	61	64	67	70	73	75	77	79	79
6,600	58	59	59	61	63	66	69	72	75	78	80	81	82
6,800	60	60	61	63	65	68	71	74	77	80	82	83	84
7,000	62	62	63	65	67	70	73	76	79	82	85	86	87
7,200	63	64	65	66	69	72	75	78	82	85	87	88	89
7,400	65	65	67	68	71	74	77	80	84	87	89	91	92
7,600	67	67	68	70	73	76	79	83	86	89	91	93	94
7,800	68	69	70	72	75	78	81	85	88	92	94	.....	.....
8,000	70	71	72	74	77	80	83	87	91	94	.....	.....	.....
8,200	72	72	74	76	78	82	86	89	93	.....	.....	.....	.....
8,400	74	74	76	77	80	84	88	91	95	.....	.....	.....	.....
8,600	76	76	77	79	82	86	90	94	.....	.....	.....	.....	.....
8,800	77	77	79	81	84	88	92	.....	.....	.....	.....	.....	.....
9,000	79	79	81	83	86	90	94	.....	.....	.....	.....	.....	.....
Horizontal distances.	0 Coming.	15	30	45	60	75 Coming.	90	75 Going.	60	45	30	15	0 Going.

APPENDIX V.

FIRST RESULTS OF THE GAVRE COMMISSION CONCERNING THE PLATFORM.

The Instruction on Fire had given provisionally (note 1 to No. 2) a certain number of numerical data which can now be replaced by much more precise data.

No. 2.[1]—The practical rule suggested in No. 2 relative to the 30/55 fuse reduces the error without completely eliminating it. Tables II and II*a*, given at the end of this appendix, give definitely the exact difference between the fuse-setter range and the true range, both for the 30/55 fuse and for the 22/31 fuse.

As far as concerns high-explosive shells, the practical rule given in the Instruction on Fire may be considered as exact until the publication of the results secured at Gavre.

No. 13. Correction for wind—Methods based on the actual speed.—The corrections for wind are given with sufficient approximation and in absolute value by the formulæ of Appendix III.

$$Cd = 2.2\ W \sin \varphi \text{ (deflection).}$$

$$Cs = 0.42 \frac{h}{1000} W \cos \varphi \text{ (site).}$$

Their direction is that given in the Instruction on Fire.

Methods based on the true speed.—For a 10-meter cross wind, the correction in direction to be made is about equal (in mils) to the number of kilometers of the range, multiplied by 2.5.

For a fore-and-aft wind of 10 meters, the correction in height to be made is about equal to the number of kilometers of the altitude, multiplied by 2.5.

In both cases the fire must always be carried toward the side from which the wind blows (lower the fire if the wind comes from the airplane toward the gun).

No 14. Deflection.—For the 30/55 shell (results are not yet known for the other shells) the deflection depends especially on the fuse-setter range. It increases very slowly with the altitude. The average deflection is about:

1 mil to 3,000 fuse-setter range.
2 mils to 4,000 fuse-setter range.
3 mils to 5,000 fuse-setter range.
4 mils to 6,000 fuse-setter range.
7 mils to 7,000 fuse-setter range.
10 mils to 8,000 fuse-setter range.
12 mils to 9,000 fuse-setter range.

No. 29. Secondary corrections of altitude.—(1) *Case of adjustment by the distance* (or more generally the case in which

[1] The numbers mentioned in this appendix are those of the Instruction on Fire.

the correction of site due to the wind is not laid off on the altitude telemeter).

Methods based on the actual speed.—Fifty meters is an average figure. More exactly, and for a fore-and-aft wind of 10 meters, the correction in altitude to be made is about 20 times the number of kilometers of the altitude.

Methods based on the true speed.—For a 10-meter fore-and-aft wind, the correction in altitude to be made is about 25 times the number of kilometers of the altitude. (Transformed into modification in site, the correction to be made would be about double that of the gun, or five times the number of kilometers of the altitude.)

(2) *Case of adjustment by the altitude* (or, more generally, case where the corrections for wind made in the site of the gun are laid off on the altitude telemeter).

Methods based on the actual airplane speed.—No change from the Instruction on Fire.

Methods based on the true speed.—The correction of site given the gun (see No. 13 corrected), and consequently the telemeter, is almost sufficient correction for the influence of the wind.

For greater precision, make a supplementary correction equal to 10 times the number of kilometers of the altitude for a 10-meter fore-and-aft wind (this supplementary correction would be practically important only for very high winds and altitudes).

No. 42.—If the trial fire is not perpendicular to the wind, the influence of the wind can be allowed for by applying the practical rule given above (No. 13 corrected).

In setting the corrector, remember that the protection given the vital parts of the airplanes is constantly being improved. It follows that the typical heights given in the Instruction on Fire are rather high. The normal corrector may well be lowered one or two divisions.

No. 46.—Read 37° 55′ instead of 38° 55′, which was an error in printing. The tables of No. 46 give the inclinations taken by the gun during a real fire executed with the old data. All posts which have not yet received the new elevation-apparatus plates must continue to use them. In this way, the trial fire, for the range at which it is made, will correct the errors of the day, and, at the same time, will also correct the rather unimportant errors due to the elevation and the telemeter.

Posts which have received new plates should determine the angle to be given the gun, adding to the site read on the altitude telemeter, set at the chosen altitude and range, the angle of fire read on Table I or I*a*.

Relative to the determination of the ballistic error in altitude, it is certain that trial fire gives its full results only for posts which have both a well-graduated elevation sight and a telemeter graduated in the fuse-setter ranges. Otherwise, the zone in which the determined error is of value is very small.

TABLES MENTIONED IN THE INSTRUCTION ON FIRE.

Tables I and II give the angles of fire and the fuse-setter ranges for shells of 30/55 and 22/31 fuse.

The Tables III and IV mentioned in the Instruction on Fire (No. 13) are rendered useless by Appendix III.

The new Table III gives the time of flight (30/55 and 22/31).

TABLE I.—*Angles of elevation in terms of the fuse-setter range (B) and of the altitude (h).*

[Expressed in degrees and tenths of degrees.]

[Shrapnel with 22/31 fuse (*Vo.*=535m.). Based on the experiments at Gavre.]

B \ *h*	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500
m	°	°	°	°	°	°	°	°	°
2,000	2.4	2.3	1.8	......	......	......	......	......	......
2,500	3.5	3.4	3.1	2.4	......	......	......	......	......
3,000	4.6	4.6	4.3	3.9	3.2	......	......	......	......
3,500	5.8	5.8	5.7	5.4	4.8	4.0	......	......	......
4,000	7.2	7.2	7.2	6.9	6.5	5.9	4.8	......	......
4,500	8.7	8.8	8.8	8.7	8.4	7.9	7.2	6.0	......
5,000	10.3	10.5	10.6	10.5	10.3	10.0	9.4	8.4	6.9
5,500	12.1	12.4	12.6	12.6	12.5	12.2	11.7	10.9	9.6
6,000	14.2	14.5	14.7	14.8	14.8	14.6	14.2	13.5	12.4
6,500	16.3	16.7	17.1	17.3	17.4	17.3	16.9	16.3	16.4
6,900	18.2	18.7	19.1	19.4	19.6	19.6	19.3	18.7	17.7

TABLE I*a*.—*Angles of elevation in terms of the fuse-setter range (B) and of the altitude (h).*

[Expressed in degrees and tenths of degrees.]

[Shrapnel with 30/55 fuse (weight, 7.365 kgs.; *Vo.*=525 m.). Based on the experiments of Gavre.]

B \ h	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500
m	°	°	°	°	°	°	°	°	°
2,000	2.3	2.1	1.6	......	......	......	......	......	......
2,500	3.3	3.1	2.8	2.2	......	......	......	......	......
3,000	4.3	4.2	4.0	3.6	2.9	1.0	......	......	......
3,500	5.5	5.4	5.3	5.0	4.5	3.6	......	......	......
4,000	6.7	6.7	6.7	6.5	6.2	5.6	4.6	......	......
4,500	8.1	8.2	8.2	8.1	7.9	7.4	6.7	5.5	......
5,000	9.6	9.7	9.8	9.8	9.7	9.2	8.7	7.8	6.5
5,500	11.2	11.4	11.5	11.6	11.5	11.3	10.8	10.1	9.1
6,000	12.8	13.1	13.3	13.4	13.4	13.3	13.0	12.4	11.4
6,500	14.7	15.1	15.4	15.6	15.7	15.7	15.5	14.9	14.1
7,000	16.8	17.2	17.6	17.9	18.2	18.2	18.0	17.6	16.8
7,500	18.9	19.5	20.0	20.4	20.7	20.8	20.7	20.3	19.5
8,000	21.4	22.2	22.8	23.3	23.8	2[illegible].0	24.0	23.6	22.8
8,500	24.2	25.1	25.9	26.5	27.2	27.5	27.5	27.2	25.9
9,000	28.4	29.5	30.5	31.5	32.3	32.6	32.6	......	......
9,500	31.4	32.6	33.8	34.9	35.9	36.5	......	......	......

TABLE II.—*Shrapnel with 22/13 fuse; Vo.=535 m.*

[Corrections to be made in the true range *D* to obtain the fuse-setter range *B* (in the table, differences *B-D* are given in terms of *D* and of *h*) (based on the experiments at Gavre).]

D \ h	0	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000
500	+215	+185	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	+165	+145	+120	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,500	+145	+115	+ 85	+ 60	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,000	+140	+100	+ 60	+ 25	− 5	.....	.....	.....	.....	.....	.....	.....	.....
2,500	+140	+ 95	+ 50	+ 5	− 35	− 75	.....	.....	.....	.....	.....	.....	.....
3,000	+145	+ 90	+ 40	− 10	− 55	−100	−145	.....	.....	.....	.....	.....	.....
3,500	+150	+ 90	+ 30	− 25	− 70	−115	−160	−205	.....	.....	.....	.....	.....
4,000	+155	+ 85	+ 20	− 35	− 85	−130	−175	−220	−260	.....	.....	.....	.....
4,500	+160	+ 80	+ 15	− 40	− 95	−140	−180	−220	−255	−285	.....	.....	.....
5,000	+160	+ 75	+ 10	− 45	− 95	−140	−180	−220	−250	−265	−260	.....	.....
5,500	+155	+ 65	+ 5	− 55	−100	−140	−175	−205	−220	−215	−200	−185	.....
6,000	+1[illegible]5	+ 60	+ 0	− 50	− 95	−130	−160	−175	−170	−140	− 85	+ 20	+220
6,500	+135	+ 55	− 5	− 50	− 85	−115	−125	−115	− 70	+ 35	+255	.....	.....
6,900	+125	+ 50	− 5	− 45	− 75	− 90	− 80	− 25	+120	+500	.....	.....	.....

TABLE II*a*.—*Shell with 30/55 fuse; Vo.=525 m.*

[Corrections to be made in the true range *D* to obtain the fuse-setter range *B*. (In the table, differences *B–D* are given in terms of *D* and of *h*, based on the experiments at Gavre.)]

D \ h	0	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500
500	+180	+135	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	+190	+145	+135	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,500	+195	+155	+130	+125	.....	.....	.....	.....	.....	.....	.....	.....
2,000	+205	+160	+125	+100	+ 65	.....	.....	.....	.....	.....	.....	.....
2,500	+210	+165	+120	+ 75	+ 30	0	.....	.....	.....	.....	.....	.....
3,000	+220	+165	+110	+ 55	+ 5	− 30	− 50	.....	.....	.....	.....	.....
3,500	+225	+160	+ 95	+ 40	− 15	− 65	− 95	−120	.....	.....	.....	.....
4,000	+230	+150	+ 85	+ 30	− 30	− 90	−125	−165	−205	.....	.....	.....
4,500	+235	+145	+ 80	+ 20	− 40	−105	−145	−190	−215	−250	.....	.....
5,000	+245	+150	+ 75	+ 15	− 45	−115	−155	−200	−220	−235	−240	.....
5,500	+250	+155	+ 80	+ 20	− 45	−110	−160	−195	−210	−210	−195	−180
6,000	+260	+165	+ 85	+ 20	− 40	− 95	−140	−175	−180	−165	−120	− 45
6,500	+270	+175	+ 95	+ 30	− 25	− 70	−105	−125	−110	− 50	+ 50	+185
7,000	+230	+185	+110	+ 50	0	− 35	− 45	− 25	+ 30	+175	+610	.....
7,500	+295	+205	+135	+ 80	+ 45	+ 40	+ 65	+160	+470	.....	.....	.....
8,000	+310	+235	+175	+140	+130	+180	+335	.....	.....	.....	.....	.....
8,500	+330	+270	+235	+240	+330	.....	.....	.....	.....	.....	.....	.....
9,000	+360	+330	+370	+470	.....	.....	.....	.....	.....	.....	.....	.....
9,500	+430	+490	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE III.—*Time of flight in terms of the fuse-setter range and of the altitude.*

[Shell with 22/31 fuse; *Vo.*=535 m. Based on the experiments at Gavre.]

B \ h	0	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000
500	0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	1.7	1.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,500	3.0	3.1	3.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,000	4.4	4.5	4.7	4.8	5.0	.....	.....	.....	.....	.....	.....	.....	.....
2,500	5.9	6.1	6.3	6.5	6.7	6.9	.....	.....	.....	.....	.....	.....	.....
3,000	7.5	7.7	8.0	8.2	8.5	8.7	9.0	.....	.....	.....	.....	.....	.....
3,500	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.3	.....	.....	.....	.....	.....
4,000	10.9	11.2	11.6	12.0	12.3	12.7	13.1	13.4	13.8	.....	.....	.....	.....
4,500	12.8	13.2	13.6	14.1	14.5	14.9	15.4	15.8	16.3	16.7	.....	.....	.....
5,000	14.9	15.3	15.8	16.3	16.8	17.3	17.8	18.3	18.8	19.3	19.8	.....	.....
5,500	17.1	17.6	18.1	18.6	19.2	19.8	20.4	20.9	21.5	22.1	22.7	23.3	.....
6,000	19.3	19.9	20.5	21.1	21.8	22.4	23.1	23.8	24.5	25.2	25.9	26.6	.....
6,500	21.5	22.3	23.0	23.8	21.5	25.2	26.0	26.8	27.6	28.4	29.3	30.1	31.0
6,900	23.7	24.4	25.2	26.0	26.9	27.7	28.6	29.5	30.4	31.3	32.3	33.3	.....

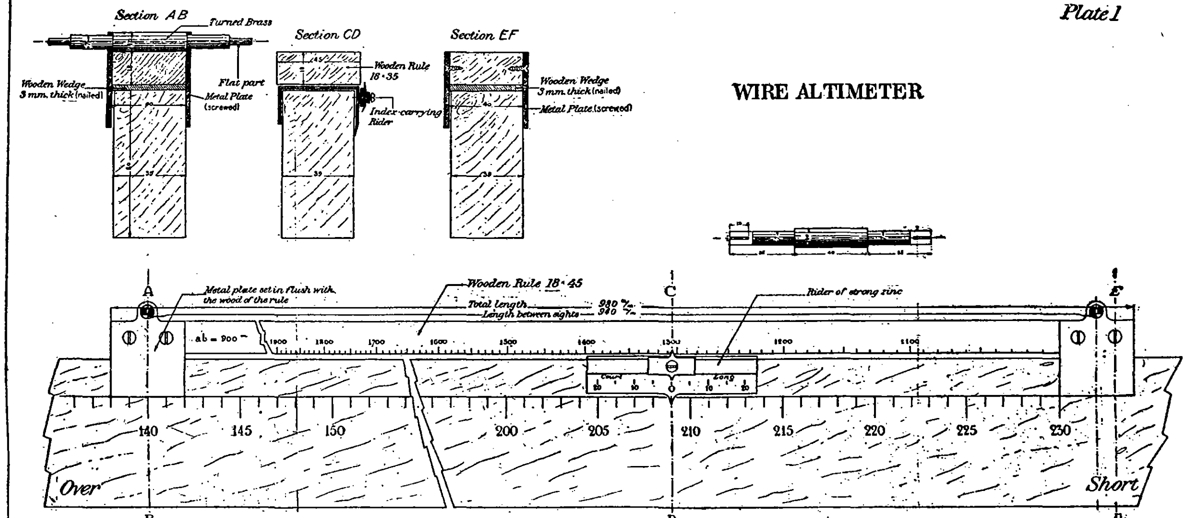
TABLE IIIa.—*Time of flight in terms of the fuse-setter range and of the altitude.*

[Shell with 30/50 fuse; *Vo.*=525 m. Based on the experiments at Gavre.]

B \ h	0	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000
500	0.67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	1.78	1.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,500	2.96	3.0	3.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,000	4.23	4.3	4.5	4.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,500	5.63	5.8	6.0	6.2	6.4	.....	.....	.....	.....	.....	.....	.....	.....
3,000	7.19	7.4	7.6	7.9	8.2	8.4	8.6	.....	.....	.....	.....	.....	.....
3,500	8.85	9.1	9.4	9.7	10.0	10.4	10.7	10.9	.....	.....	.....	.....	.....
4,000	10.61	10.9	11.3	11.6	12.0	12.[illegible]	12.8	13.2	13.6	.....	.....	.....	.....
4,500	12.44	12.8	13.2	13.7	14.1	14.6	15.0	15.5	15.9	16.3	.....	.....	.....
5,000	14.34	14.8	15.3	15.8	16.2	16.8	17.3	17.8	18.3	18.9	19.4	.....	.....
5,500	16.33	16.9	17.4	18.0	18.5	19.1	19.7	2[illegible].3	20.9	21.5	22.1	22.8	.....
6,000	18.41	19.1	19.7	20.3	20.9	21.5	22.2	22.9	23.6	24.3	25.0	25.7	.....
6,500	20.6[illegible]	21.3	22.0	22.7	23.4	24.1	24.9	25.7	26.5	27.3	28.1	28.9	29.7
7,000	22.9[illegible]	2[illegible].7	24.5	25.3	26.1	26.9	27.7	28.6	29.[illegible]	3[illegible].4	31.4	32.4	33.4
7,500	25.[illegible]5	26.2	27.1	28.0	28.9	29.8	30.8	31.8	32.8	33.8	35.[illegible]	36.2	.....
8,000	27.96	28.9	29.9	3[illegible].9	32.[illegible]	33.[illegible]	34.1	35.2	3[illegible].4	3[illegible].7	....	.....	.....
8,500	3[illegible].8[illegible]	31.9	33.0	34.2	35.4	36.6	37.9	3[illegible].[illegible]	....	....	...	.....	.....
9,000	3[illegible].9[illegible]	3[illegible].2	36.4	37.8	39.2	40.7	...	...	...	...	...	...	.....
9,500	37.4	38.9	40.4	42.0	43.7	...	...	...	...	...	...	...	.....

Plate 1

WIRE ALTIMETER



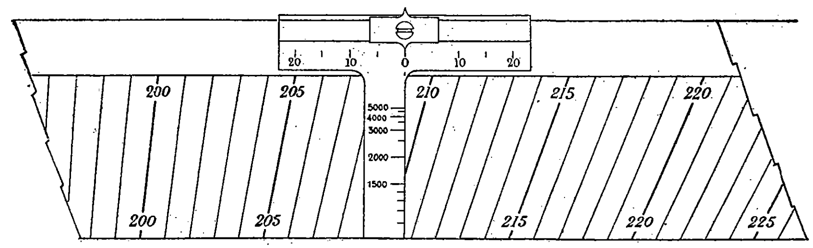
Length of the rule 3 m.; the cross wire at 1.3 m. from the left end. Direction of Observation Station ⟶

Plate 2

WIRE ALTIMETER

Rider in the case of the Observation Station being 100 meters above the battery.

Actual size



The 130 mark is vertical

Space between the lines { *Upper part 10 mm.* / *Lower " 9 "*

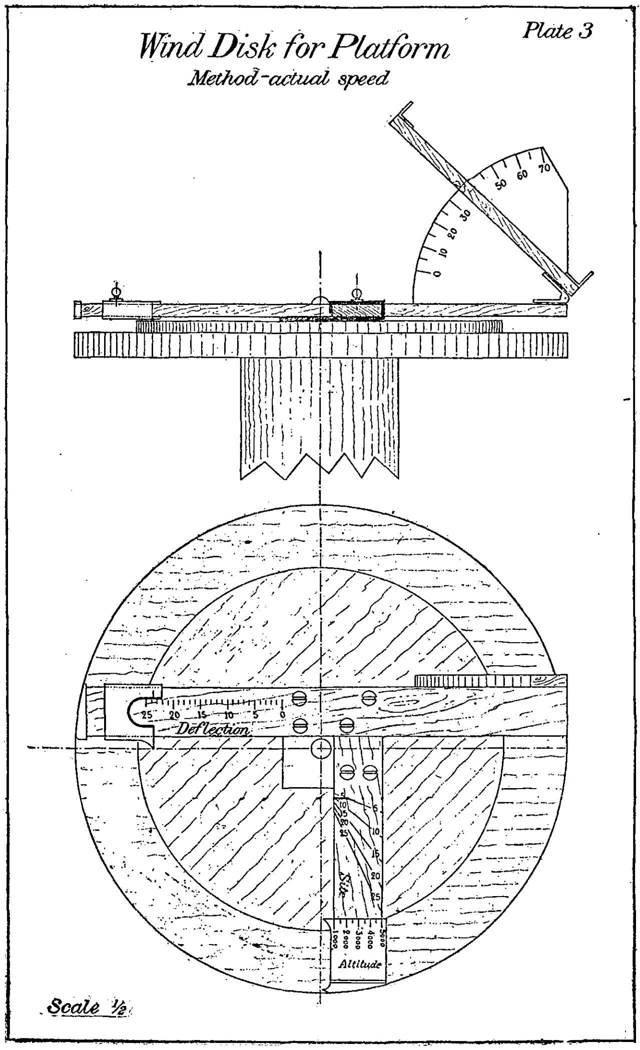
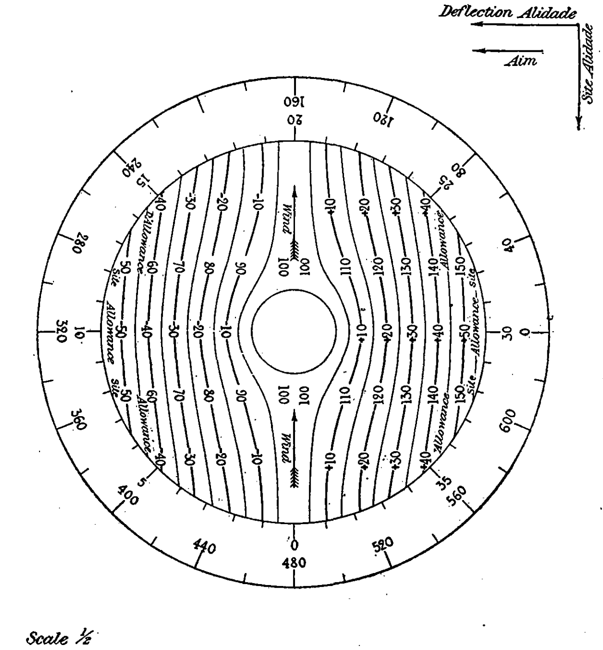

Wind Disk for Platform
Method-actual speed
Plate 3
0 10 20 30 50 60 70
25 20 15 10 5 0
Deflection
Site
Altitude
Scale ½

Plate 4.

Wind Disk for Platform.

Method—actual speed.



NOTES ON LATERAL OBSERVATION OF FIRE ON AEROPLANES, USING SIMPLE FIELD APPARATUS (SUPPLEMENT NO. 1).

(From the French School of Fire at Arnouville, May, 1916.)

NOTE ON LATERAL OBSERVATION.

(The demonstration of formulæ is given in an Appendix.)

The Arnouville School has long recommended the use of a wire C L, placed at the distant post, at about 1 meter above the eye and parallel to the base. The observer places himself so that the wire is projected nearly on the aeroplane. Rounds are short or over depending on whether they are seen on the side toward the stake marked short (side toward the battery), or on the side toward the stake marked over (the opposite side). A very simple modification permits a knowledge of how short or how far over the rounds are.

(A) *We shall first suppose that the rounds burst exactly on the line-battery aeroplane.*—I. Take for the wire C L a small cord having a series of equally-spaced knots ,the interval between which is d, or a metal wire on which are threaded and fixed a series of beads spaced the same distance apart.

Carefully level the ground under the wire.

Place the wire at the height a above the eye O.

Take $a=10d$. (NOTE.—If $d=10$ centimeters, $a=1$ meter when the altitude h of the aeroplane is equal to the base b.

Vary a proportionately to h in any way, for example by setting in the posts P, P' a series of nails over which the wire C L passes.

Raise or lower the wire according to the altitude.

Graduate P and P' accordingly.

When this has been done, to observe a round the observer places himself as usual so that the wire is projected on the aeroplane. As soon as a round bursts, he looks to see what is the extent of the error given by the number of knots, and he reports: "Short (or over) n knots (n intervals)."

Whatever be the position of the aeroplane, these n knots represent an error in range of n tenths, that is to say, the proportion of the error to the distance is $\frac{n}{10}$, and the increase of the altitude $\triangle h$ which must be ordered is equal to $n \times \frac{h}{10}$.

Example: The aeroplane has an altitude of 3,500 meters. The report is "2 knots short." Order "Altitude + 700."

The correction for altitude depends only on the number of the knots.

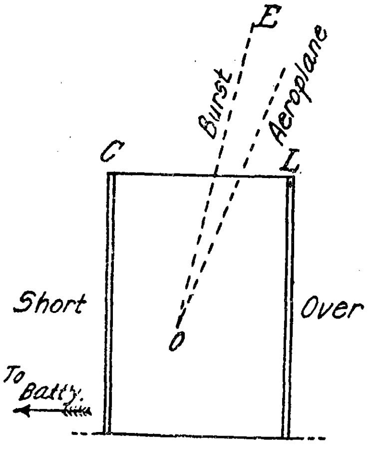


Fig.1.

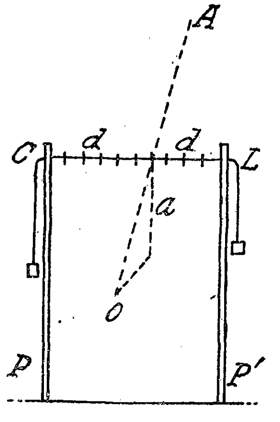


Fig.2.

It is independent of the position of the aeroplane.—(See the demonstrations in the Appendix, Theorem "of the knotted rope.")

II. Means of rendering constant the absolute correction which is to be ordered.

It is sufficient to make the height of the wire vary proportionately to the square of the altitude. Then the unit of measure adopted (a knot) corresponds to a constant correction of altitude.

The relation between the interval d to be given the knots and the corresponding correction Δh is shown by the formula (see Appendix):

$$d=\Delta h\times\frac{a}{h^2}\times b.$$

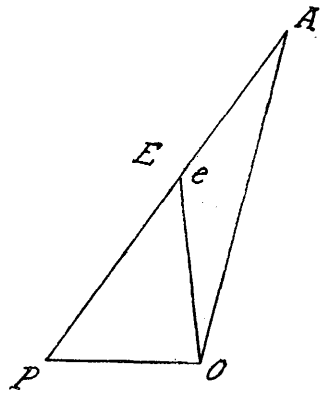


Fig. 3.

We can take:

$$\Delta h=200 \text{ meters}$$
$$\text{and } a=0.30 \text{ meter}$$
$$\text{for } h=2{,}000 \text{ meters.}$$

From this we shall deduce d.

This variant of the method is very highly recommended.

A third variant consists in leaving the wire at a fixed height, the spacing of the knots corresponding to $\Delta h=200$ for $h=3{,}500$. It will be known by heart that a knot does not represent more than 100 meters at 2,500 meters. We can also place several cords, each corresponding to a certain altitude.

III. *Case where the round is seen outside the wire.*—*P*—piece; *O*—observer; *A*—aeroplane.

In general, the bursts are not very far from the plane $O\ P\ A$. In any case, what must be looked for is the *projection e of the burst E on the plane O P A*, a projection which is made by judgment. One can practise projecting by judgment any point E on the plane $O\ P\ A$ by using a sort of rake or comb, which one holds at arm's length in a plane perpendicular to the line of sight and so that its lower edge is projected on the wire

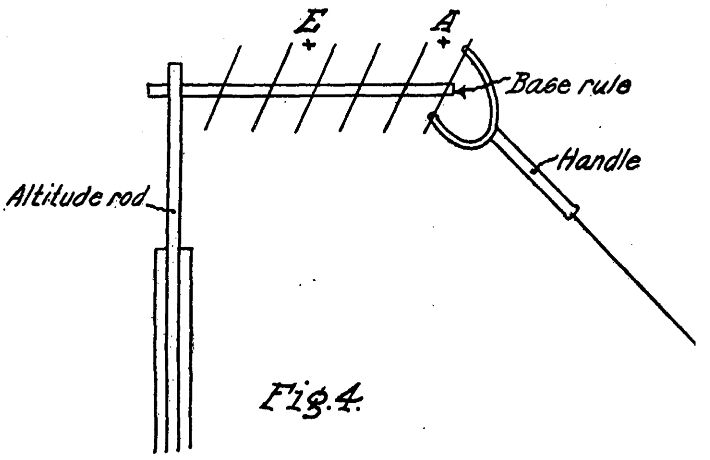


Fig. 4.

$C\ L$. The direction of the teeth gives that by which the point E must be projected.

IV. *Arnouville observation rake.*—We are having built for us, on the principles which have just been explained, a trial apparatus called an "*observation rake*," the teeth of which automatically orient themselves perpendicular to the plane $O\ P\ A$ and have a separation equal to that of the knots. In this way the projection of E on e is made with certainty.

The base rule of the rake turns in a socket carried on an altitude rod which is raised or lowered proportionately to the square of the altitude. One of the teeth forms, with the base rule, the crossbar of a gimbal-mounting, the handle of which is prolonged by a rope. By drawing on the rope one auto-

matically gives the teeth of the rake a direction perpendicular to the plane "cord—base rule." The height of the teeth of the rake is taken to be equal to twice the distance from chin to eye. To observe, then, a man need only draw on the cord, put it under the chin and move so as to see the aeroplane projected at about the height of the middle of the teeth. He then notes by how many teeth, i. e., by what altitude, the rounds are short or over. A more detailed description will be sent the armies as soon as the apparatus is perfected.

(*B*) *Influence of errors in direction and in height.*—I. An error is of importance only when it affects the projection *e*. (If, for example, the plane *O P A* is vertical, an error in direction is unimportant, but an error in height is very important.)

Let ϵ be the angular error *A P e*. The error resulting from it on the error in altitude indicated by the observer has the value (see Appendix) : $h\ \epsilon \cot p$, p being the parallax of the point *A* ($p=P\ A\ O$) ; that is to say, that a small error of 10/1000 involves errors in distance which, for a base of 3,500 meters and an aeroplane at altitude 3,500, are normally of 100 to 150 meters, and may, in certain cases unfavorable to observation (the aeroplane at the opposite side of the distant post), be as high as 400 meters. Diagrams 1, 2, and 3, at end of text, make the matter clear.

Diagram 1.—Aeroplane at height of 3,500 meters.

Base of 3,500 meters. *P*—piece; *O*—observing station.

Inside of curve 1, an error of 10/1000 in direction (error in the plane *P O A*) involves an error in altitude of less than 35 meters $\left(\frac{h}{100}\right)$.

The error is double on curve 2, triple on curve 3, etc.

If the error is 20/1000, all these figures must, of course, be doubled.

We may say that the only region rather favorable for observation is the region inside curve 2, which embraces about half the area of possible fire. Inside this region, if the errors in direction or height do not exceed 20/1000, the error committed in the correction of altitude does not exceed 140 meters.

Diagram 2.—Aeroplane at 3,500 meters. Base of 2,500 meters.

Region 2 is now only one-fifth of the area of action. The deduction from this is that the base of 2,500 meters is *wholly*

insufficient. (We shall later see a means of using under favorable conditions a base of 2,500 meters when circumstances make it necessary.)

Diagram 3.—Aeroplane at 3,500 meters. Base of 5,000 meters. Area 1 is almost as large as area 2 of example 1.

Precision is increased about two-thirds. But observation is still bad in the opposite direction from *O*. Furthermore it is rarely possible, in view of the distance.

These conclusions are, of course, independent of the rake process or of the knotted cord, but hold good for any method

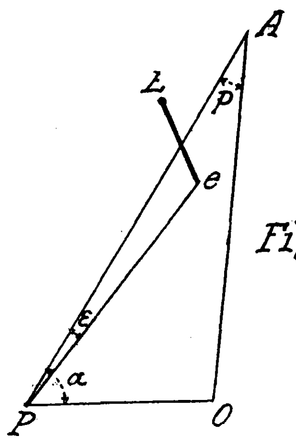


Fig. 5.

of unilateral observation where the errors are counted parallel to the plane *P O A*.

II. MEANS OF CONSIDERABLY REDUCING ERRORS.

1. *Process of symmetrical observers.*—It follows from the foregoing that *in order to be able to observe everywhere, we must have at least two posts.* Examination of diagrams 1, 2, and 3 shows that the most advantageous way to place them is to put them opposite one another and at nearly the same distance (equal bases). If there are three posts, they will, of course, be put at the vertices of an equilateral triangle.)

By taking the mean of the corrections ordered by the two posts the error due to a deviation ϵ is almost always considerably reduced. This error, estimated in altitude, has the value:

$$h\epsilon \frac{\cot p^1 - \cot p}{2}$$

and it is easy to see that $\frac{\cot p' - \cot p}{2} = \cot \alpha$. (Theorem of symmetrical rakes. See Appendix.) The error therefore is: $h\epsilon \cot \alpha$, instead of: $h\epsilon \cot p$.

Now, α is almost always much greater than p. The advantage is especially notable when the bases are medium or

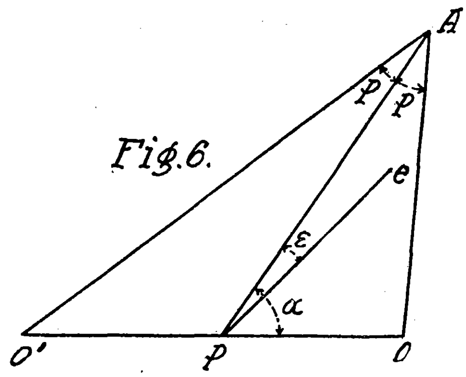


Fig.6.

small. The angle α is, indeed, *independent of the common length of the bases.* The *theoretical* precision of the process of *symmetrical* observing posts is, then, independent of the distance of the posts. But, in practice, we must always have bases which, if not very great, are at least medium (*2,500 at least*). Indeed, posts O' and O' are never exactly "symmetrical," and, above all, the errors measured by O and O' (with the aid of the cord or rake), which we have assumed to be strictly exact, never are so. The errors which result from this *are so much the larger in proportion as the common base is smaller.* Diagrams 4 and 5 make these points clear.

Diagram 4.—Altitude *3,500.* (The curves are independent of the base.)

Curves ½, 1, 2, 3 have the same signification as above.

They are the curves for which: $\cot \alpha = \frac{\cot p' - \cot p}{2}$ has, respectively, the values ½, 1, 2, 3.

Inside of the area I/II limited by ½, an error equal to 10/1000 involves an error in the altitude of less than 17.5 meters.

The error is included between 17.5 and 35 meters in area I and between 35 and 70 meters in area II.

Curve 2 now embraces *almost the whole area of action.*

Diagrams 5 and 6.—Still with symmetrical observing posts. Comparison between the process of taking the mean and the process of taking into account only the observations of that one of the two posts which is on the side toward the aeroplane.

If b is $<h$, cot p is always$>$ cot α, and there is always advantage in taking the mean. (Compare diagram 4 with diagrams 1 and 2.

If b is distinctly $>h$ there is over each post a small region in which it would be advantageous to take account only of the observations of the post which is being flown over (diagrams 5 and 6). This region is limited by a circle having for center the observing post, and for radius $\sqrt{b^2 - h^2}$. (Theorem of the orthogonal circle. See Appendix.) This region becomes important only if the base is very large.

Diagram 6*a* gives an example of this.

The bases are assumed equal to 5,000 meters, the altitude equal to 2,500 meters.

Outside the circles a and a' we must take the mean of the observations of O and O', and the curves ½, 1, 2 have the usual form. Inside the circles a and a' we need take account only of the observations of the post flown over.

Under these conditions the area embraced by 1 (error of altitude less than $\frac{h}{100}$ for E=10/1000) includes nearly the whole area of action.

2. *Process of two conjugate rakes.*—A result identical with the foregoing is obtained with a single distant observer, and consequently without the trouble of establishing two *equal and opposite* bases (a thing which is not always possible) by the following process, which is called the process of the two conjugated knotted cords or of the two conjugated rakes:

A knotted cord (or rake) is installed at O as before. A second cord (or a second rake) is installed at the battery, according to the same principles, the observer placed at P installing his cord and observing his rounds as if it were O who was firing. (The side toward O will therefore be the side of the short rounds.)

When this has been done the corrections ordered by P and O are added algebraically (instead of taking their mean, as was done with O and O').

The correction obtained is given to the altitude telemeter and has the effect of guiding the rounds *to* e', i. e., on a parallel to

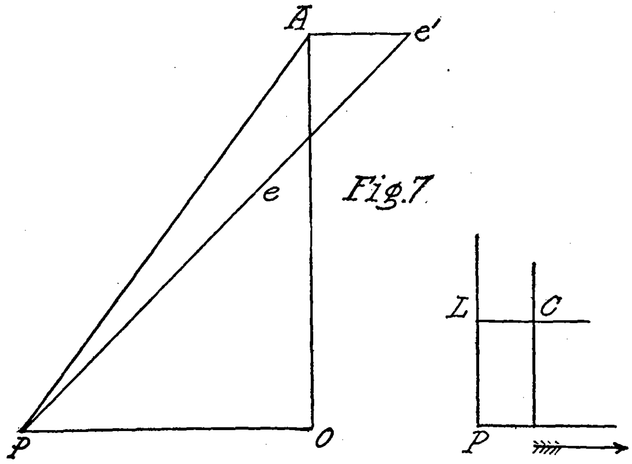


Fig. 7

the base drawn by the aeroplane (theorem of the conjugated rakes). (See Appendix.)

The error resulting from this way of operating is now equal only to $h\ \epsilon \cot \alpha$; that is to say, *it is the same as the error of the process of the two symmetrical observing posts.*

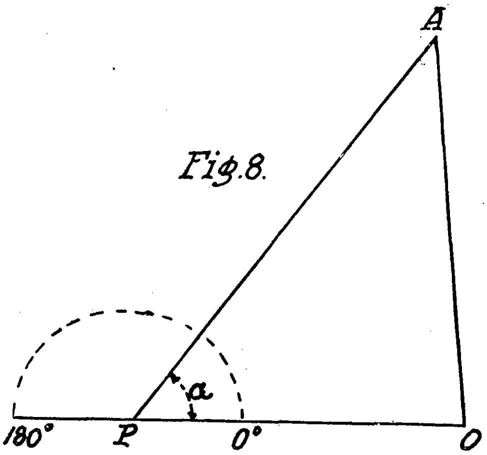
Example.—At P and O are put two knotted cords, which can be moved on a vertical scale graduated proportionately to *the square of the altitude.*

O reports "Short 600" (or "Short 3 knots"), which means short 600 meters in altitude.

P reports "Short 200" (1 knot).

Δh is taken =800. (With the process of the symmetrical observers, if O reports "Short 600" and O' "Short 200," we take Δh=400.)

The theoretical precision of the process is the same as that given by the two symmetrical observing posts. In practice, when the aeroplane is on the side opposite to O, the observation is not so easy, *because O can not see well.* With the process of the symmetrical observing posts, if O can not see well, we take account only of the observations of O'. We even know that in many cases (b being $>h$ and observing post being flown over) superior precision is obtained in this way. It is still better to



have *three observing posts,* one at O, another at P, the third at O'. Dependent on the region where the aeroplane is maneuvering, we combine O and P, O' and P, or we take note only of what O or O' tell us. O and O' need no longer be equidistant from P. This process is particularly recommended when post P has available a *rake with corrector,* the principle of which will be given below. By the use of this special arrangement all errors of the process of the two conjugated rakes are theoretically done away with. That is to say, this process becomes much superior to that of the symmetrical rakes.

C. *Means of entirely reducing errors.*—It is sufficient to use the process of the nonconjugated rakes and to affect the measurement made by P with a coefficient of reduction equal to $\frac{b \cos \alpha}{D}$ (α taken from 0 to 180 degrees) that is, multiply $n' \Delta h$ by $\left(1-\frac{b \cos \alpha}{D}\right)$.

The rake with corrector, which we are having made, will be so arranged as to give automatically the factor of correction $\frac{b \cos \alpha}{D}$.

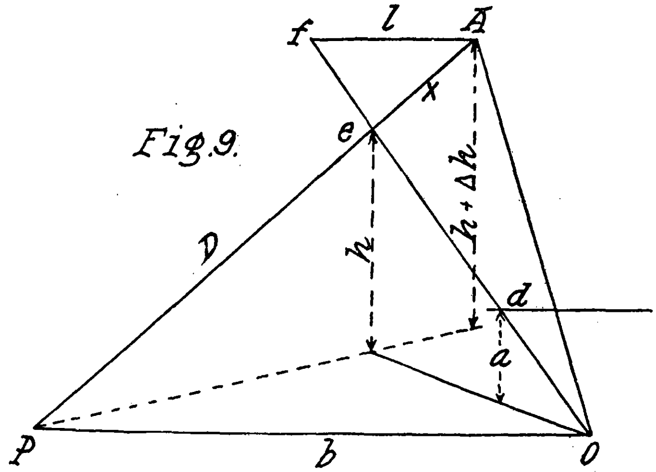


Fig. 9.

It would be equally easy to read cos α on a suitable scale placed below the gimbal mounting and to prepare a simple table giving $\frac{b \cos \alpha}{D}$.

A complete description of the Arnouville corrector rake will be sent to the armies in a short time.

Appendix.

DEMONSTRATION OF THE FORMULAE AND PRINCIPLES MENTIONED.

1. *Rounds bursting on the line P A (theorem of the knotted cord).*—The case of a round bursting "one knot" or "one tooth" left of A.

This round is projected at f on the parallel to the base passing through A at a distance l from A, given by the formula: $\frac{l}{d}=\frac{h+\Delta h}{a}$ or approximately $\frac{l}{d}=\frac{h}{a}$.

Further, the two triangles *eAf*, *ePo* being similar, the relative error of range $\left(\frac{x}{D}\right)$ is given by:

$$\frac{x}{D}=\frac{l}{b}$$

But $\frac{x}{D}$ is equal to $\frac{\triangle h}{h}$. We therefore have:

$$\frac{\triangle h}{h}=\frac{l}{b}=\frac{h}{a}\times\frac{d}{b}.$$

If a is proportional to h, d being constant, $\frac{\triangle h}{h}$ will be constant. If a is proportional to h^2, $\triangle h$ will be constant.

2. *Any round which is projected at e on the plane P A O (theorem of the calibrated rakes).*—The figure at once shows

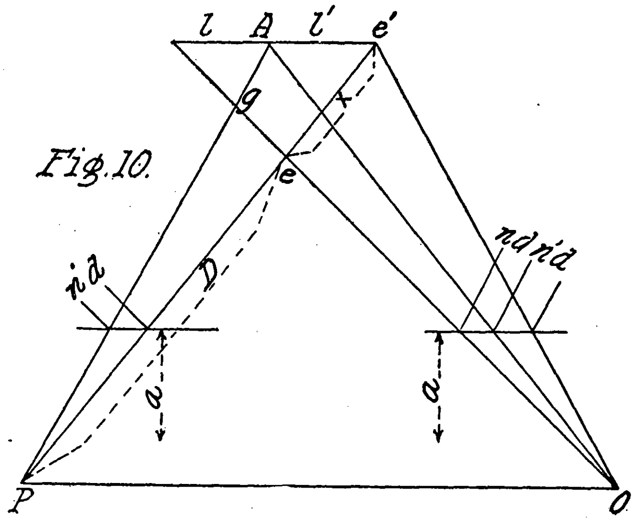


Fig. 10.

that if the aeroplane were at e' the round would be seen by o, short $n + n'$ knots. Making the corresponding correction, the round is brought from e to e'; i. e., as has been said, *on a parallel to the base which passes through the aeroplane.*

The error made in this way is equal in distance to l' cos α (that is, to $D\epsilon$ *cos* α), and in altitude to $h\epsilon$ cos α.

In the case of unilateral observation, e and g are confused, i. e., an error is made which is equal to the projection of $e\ g$ on

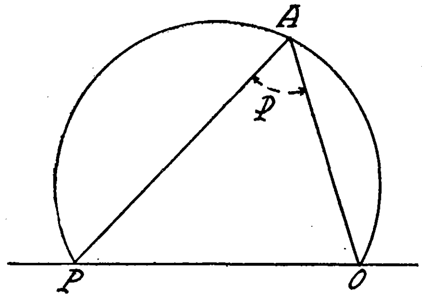
$P\ A$, a projection which is approximately equal to $D\epsilon \cos p$, whence an error of altitude $h\epsilon \cos p$.

3. *Means of doing away with all error in the case of using the double rake process (rake with corrector).*—The correction x made in the range is given by $\frac{x}{D}=\frac{l+l'}{b}$. The correction *to be made* is equal to $x—l' \cos \alpha$; that is, to $\frac{D}{b}\left[l+l'\left(1—b\frac{\cos \alpha}{D}\right)\right]$. It will therefore be obtained by affecting l'; that is, n' with the coefficient of reduction $\frac{b \cos \alpha}{D}$.

4. Curves $\cos p=a$ constant, considered in diagrams 1, 2, and 3.

The locus of points A for which $p=a$ constant is a portion of a tore, engendered by the rotation about $P\ O$ of the segment

Fig. 11.



subtended by the angle p. (A tore is a surface or solid generated by the revolution of a conic about any axis.)

Cutting this tore by the plane of altitude h, we get the curves which we are seeking.

5. To prove that $\frac{\cos p'—\cos p}{2} = \cos \alpha$ (Theorem of the symmetrical rakes).

$$\text{Cos } p'=\frac{A M'}{O' M'}=\frac{A M'}{O M}$$

$$\text{Cos } p=\frac{A M}{O M}$$

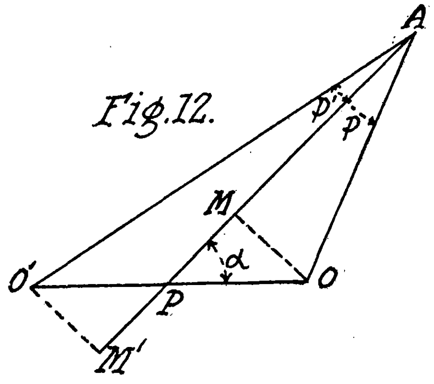
$$\text{Cos } p'—\cos p=\frac{M M'}{O M}=2\frac{P M}{O M}=2 \cos \alpha.$$

6. Locus of the points for which the error due to the process of the symmetrical observers is equal to that given by unilateral observation. (Theorem of orthogonal circles. Orthogonal circles are those which intersect each other at right angles.)

This locus satisfies the condition $\frac{\cos p' - \cos p}{2} = \cos \alpha = \cos p$ whence $\alpha = p$ and consequently $OA = OP = b$.

The locus of point A is therefore a sphere, with center O and radius b. For a determined altitude h, this locus is a circle, of which the center is on the vertical O, and of which the radius is equal to $\sqrt{b^2 - h^2}$. This circle is orthogonal to the

Fig. 12.



one which has its center on the vertical of P and which has for its radius the altitude.

CONCLUSION.

The Instructions make it obligatory for all posts of fire against aerial targets to install "lateral" observation posts. Indeed, without lateral posts:

(a) It is impossible, with the apparatus in service, to find exactly the range of a distant target. (The Barr and Stroud, with a meter base, in expert hands, can give an *idea* of the distance, and therefore of the altitude. This is better than an estimate made by eye, but it is quite insufficient. As to the suggestion that has been made that a whole method of fire be built on the so-called constancy of errors of the Barr and Stroud, that is a theory which does not bear examination.)

(*b*) It is impossible (except in the extremely rare case of very clear occultations) to conduct precise ranging. (If an accident makes all communication with the lateral observers impossible, and if use is made of the method of estimated speed, it may be assumed, as a last resort, that the rounds are very short when they are seen very far ahead, and that they are very much over when they are seen very far in the rear. But, in view of the number of factors which effect the direction, this process offers no real guarantee of accuracy. It makes the fire a little less inaccurate, but does not make it effective.)

For an isolated observer, the explosions and the aeroplanes are projected on the celestial sphere somewhat like stars, and it is impossible to differentiate their respective distances. It follows from this that, so far as concerns the determination and adjustment of the range, the lateral posts play, in respect to the firing posts, the same rôle the observation posts of defiladed batteries play toward the batteries themselves. Just as every battery commander who knows his work makes it a point of honor to be connected in an almost sure way with his battery and with the infantry, so every commander of a post should make it a point of honor to be connected by several means (electrical, visual if possible) to his distant posts. When difficulties come up, the watchword is to overcome them and not to whine. We are an army which wills to win, and the final victory will be the sum of all the small victories which each man, daily and in his modest sphere, gains over the obstacles which bar his right road.

It is not enough to have distant posts; they must be rationally organized. The above note gives the means of logically organizing the distant posts; it gives the means of calculating in each case the precision which can be counted on. These means are not yet imperative. Most of them are of recent discovery, and have not the sanction of practice. There exist other processes for knowing exactly how far a round is short or over, one of which, called the "flag process," appears to have very good possibilities. It is now being studied, and will be the subject of a special note in the near future. Others may come up.

But the thing which is imperative is to *adopt a rational organization at least equivalent to those which are given as examples.* We must not remain hidebound in our old routine when a better exists. We must not ask observers to make cal-

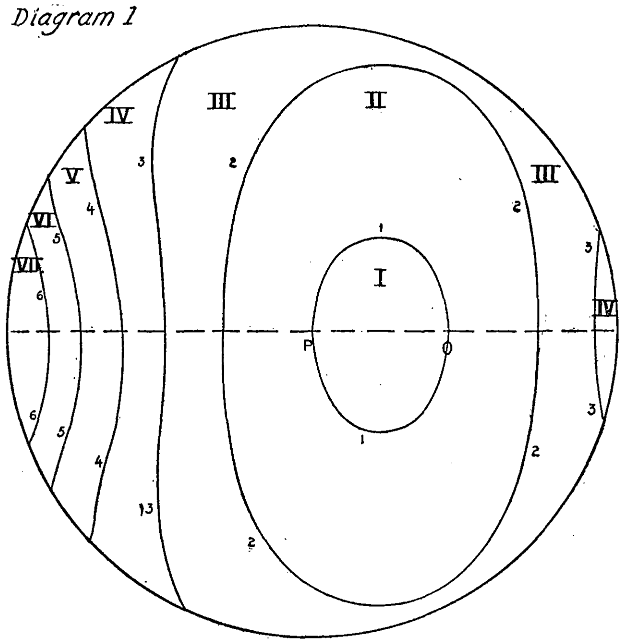
culations in solid geometry before deciding if a round is short or over when there are practical and sure ways of not making a mistake. (The string process for knowing whether a round is short or over already has the sanction of experience. Only the processes of the knotted cords, of the "rake," of the "double rake," and of the "flag" are new.) We must not take short bases when it is demonstrated that, except by the process of the two symmetrical observers or of the two conjugated rakes, a base of 3,500 meters is itself too short.

It is to be remembered that "fire by piece" is the fire best adapted for ranging. (Leaf of Corrections to the Instructions of Dec. 24, p. 394.) The error in range, estimated in correction of altitude, remains almost constant.

In automatic fire by series, known as "comb fire," it is the *mean* error of altitude which is constant. The mean to take, which theoretically should be based on 3 or 4 consecutive rounds (3 or 4, depending on the reading mechanism adopted), is often slightly falsified by the fact that the observers, even *experienced observers,* do not succeed in observing all the rounds. (Remember that an observation is good only if the observer, without taking his eyes off the aeroplane, sees the smoke at the very beginning of its formation.) It is probable that the use of the rake will increase considerably the proportion of the rounds which are *well* observed, and it may be remarked that if one succeeds in taking the average of a large number of rounds, the fact that there may be some "unobserved" does not much change the average.

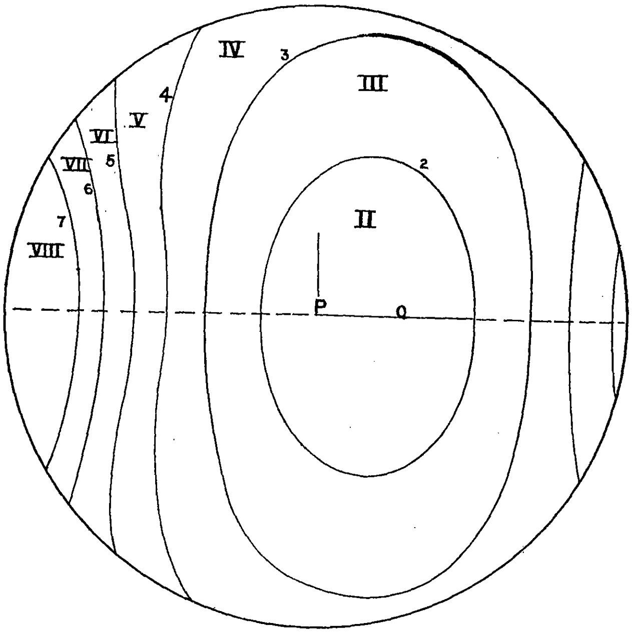
In nonautomatic fire by series (fire by 4 or progressive fire) the average error in altitude even is no longer constant. We know, indeed, that the relative depth beaten varies between 300 and 900 meters. (Leaf of Corrections, p. 42.) This is one of the reasons which cause fire by piece for the first rounds (altitude not known), and comb fire thereafter (or at once, if the altitude has been exactly measured), to be particularly recommended. (See "Choice of Mechanisms," Leaf of Corrections, p. 43.)

Diagram 1

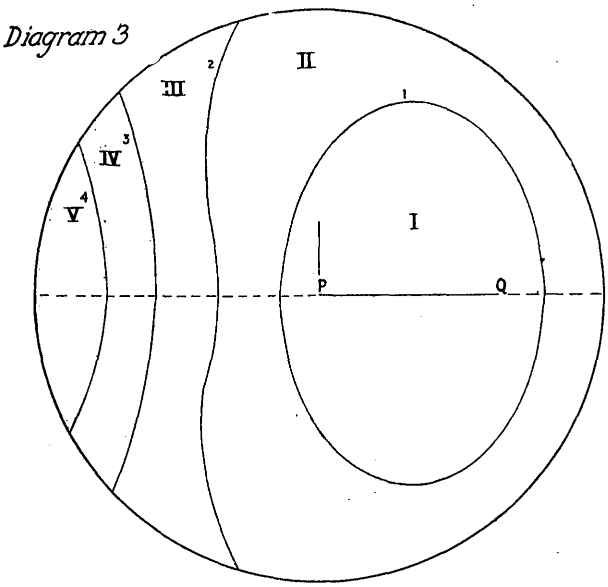


Base : 3500m
Altitude : 3500m

Diagram 2.

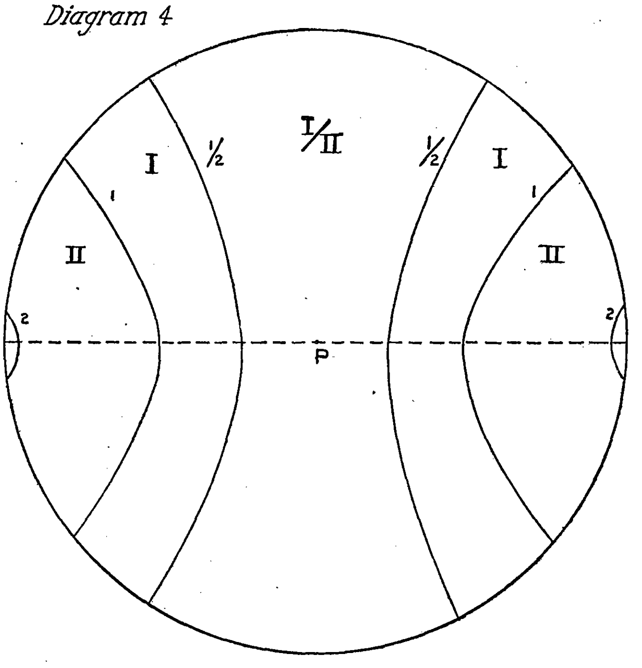


P.O. Base : 2500m
Altitute : 3500m



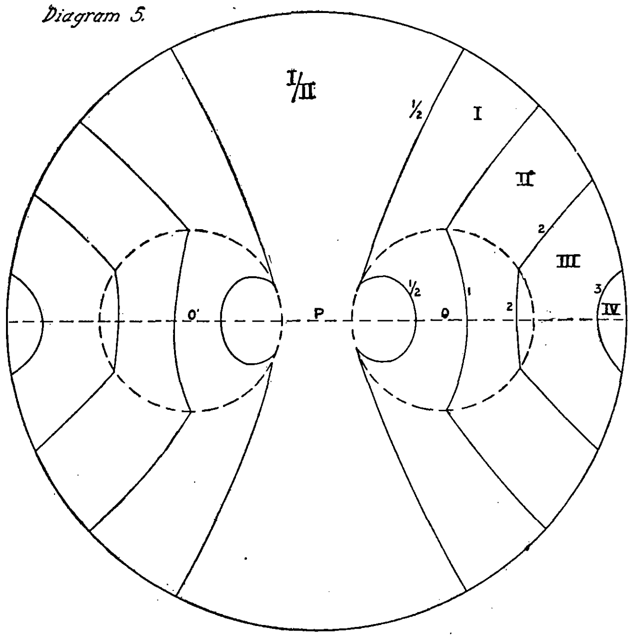
Base: 5000m
Altitude: 3500m

Diagram 4



Altitude : 3500 m

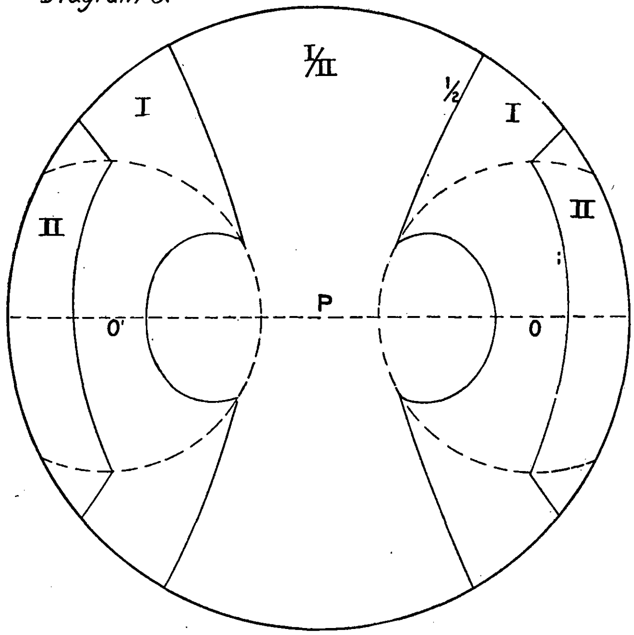
Diagram 5.



P O, P O' = Base : 3500m
Altitude : 2500m.

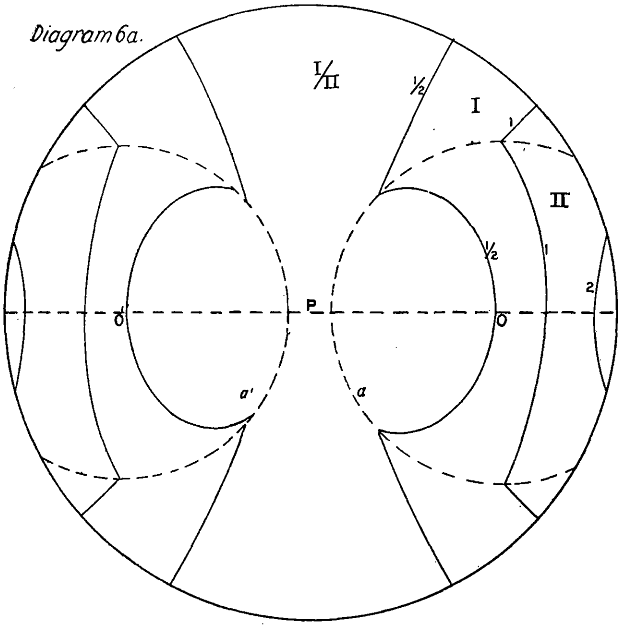
4069°—17——13

Diagram 6.



PO. PO = Base : 5000 m.
Altitude : 3500 m.

Diagram 6a.



PO – Base : 5000m
Altitude : 2500m

ADJUSTMENT OF FIRE ON AEROPLANES.—COURSE OF THE SCHOOL OF FIRE AT ARNOUVILLE.

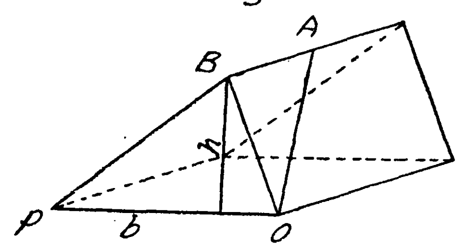
SUPPLEMENT NO. 3.

By Commandant E. PAGEZY.

I. THE STRING ALTIMETER.

" When a roof is in plumb, all the points of its ridge have the same altitude." This is the principle of most altimeters. The two slopes of the roof are formed by two sighting planes passing through two hinges perpendicular to the base $P\ O$. They pass through the aeroplane A. A section of the " altimetric roof " gives the altitude. This section is the triangle PBO of figure 1.

Fig.1.



Let us construct a miniature roof $P'B'O'$ of a constant height a and similar to the altimetric roof. Let us measure the segments l and l' which are determined on the miniature base $P'O'$ (fig. 2) by the vertical plane passing through the ridge.

The similarity of PBO and $P'B'O'$ gives:

$$\frac{h}{a}=\frac{b}{l+l'}$$

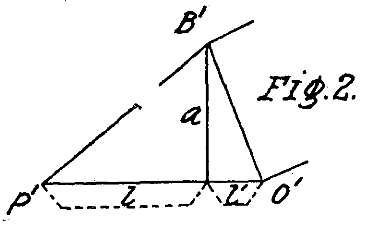
$$l+l'=\frac{a\,b}{h}$$

On a scale of $a\ b$, $l + l'$ represents the inverse of the altitude.

From these more or less well-known principles we must improvise a fire altimeter. The string altimeter is the solution

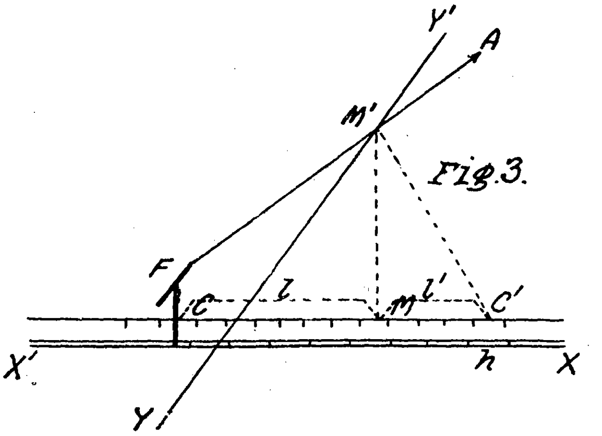
proposed by Arnouville. It is also the English solution, and it gives good results.

There is the objection of the difference in level which may exist between P and O. All fighting is not done in Flanders. A calculation for error shows that the difference of level is not



important so long as it does not exceed one one-hundredth of the base, or 30 meters for 3,000 meters of base. An effort is made to attain this. If this can not be done, it will be necessary to introduce a correction, of which we shall speak later.

Description of the string altimeter.—Let us imagine two miniature roofs, one at P, the other at O.



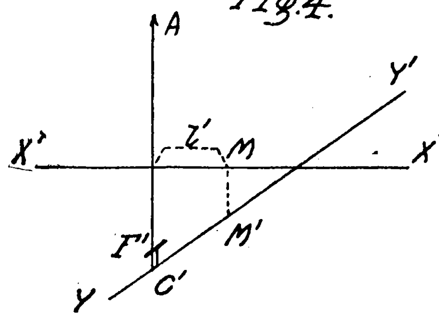
Post P.—The ridge is represented by a horizontal wire $y\ y'$ perpendicular to the base (fig. 3). The base is represented by a rail $x\ x'$, bearing a metric scale, and along which moves a wheeled rider C. The rider carries a sighting device F, parallel to $y\ y'$, and which can turn on its axis. "a" is the difference

of altitude between F and $y\ y'$. The sight F and the wire $y\ y'$ determine a sighting plane. The rider is moved back and forth until this sighting plane passes through the aeroplane. The sighting plane forms one of the "slopes" of the roof, the one corresponding to P, and the length l is found automatically registered as $C\ M$.

The same arrangement is made at post O, which registers l' on its rail, reads it, and sends it to the battery post.

P registers l' as $M\ C'$ on the scale $x\ x'$ by moving a little zinc rider C'. $C\ C' = l + l'$, and represents the inverse of the altitude h on a scale of $a\ b$. For ease in deducing h from it, an endless ribbon is attached at C, running the length of the rail

Fig. 4.



and passing over two guide pulleys at either end of it. This ribbon is graduated in $\frac{l}{h}$ of the scale $a\ b$. The altitude is read below the zero of the rider C'.

Four men are required, namely, a sighter and a reader at each post.

In the apparatus which he had built at Arnouville Capt. Bricard took a as equal to 0.30 meter. This gives the rail and the wire a length of 3 meters. The length of the rail can be reduced by replacing the single wire $x\ x'$ by two parallel wires. One wire or the other is used, depending on whether the aeroplane is on the side toward O or on the opposite side.

VARIATIONS FOR DISTANT POST.

First variation.—This variation saves a man. It consists of putting $x\ x'$ above and $y\ y'$ below. (Fig. 4.) $x\ x'$, parallel to

the base, consists of a wire bearing a metric scale formed by beads. $y\ y'$ is a rail having another rider C' equipped with a slit F'. This slit is parallel to $y\ y'$—that is, to the rail and not to the wire. It can turn about on its axis. The rider is moved so as to show the aeroplane projected on $x\ x'$, and the length l' is read directly. One man may be sighter, reader, and telephoner.

Second variation.—The slit F' can be replaced by a simple horizontal wire $y\ y'$, which makes the rail and its rider unnecessary. The apparatus becomes much more simple. It is now formed only of two strings. But the sighting will probably not be so easy nor so precise. In an extreme case the battery post can also consist of two similar wires, the upper wire permitting l to be read.[1] A simple calculation gives h as a function of $l+l'$. This shows that it is possible to mark an altimeter of four simple strings.

Sending the location of the aeroplane to a distant post.—The altitude is estimated. This done, on C′ (Fig. 3) the length l′ is read, which indicates to O the place where the rider should be placed. It is easy to see that the aeroplane is projected on $y\ y'$ at a distance from M', which is *the same for both posts.* Beads placed on $y\ y'$, spaced 50 centimeters apart, permit this distance to be read and to be sent to the distant observer. It is the second coordinate of the aeroplane. Its direction is now defined.

Case where the difference of level of the posts exceeds b/100.—At each post the rail $x\ x'$ is given an inclination ϵ equal to that of the base, the distance between $x\ x'$ and $y\ y'$ taken along the vertical $M\ M'$ being always equal to a.

h' being the altitude measured as usual, figure 5 shows that the value of the real altitude h is:

$$h=h'+P\ H\times\epsilon=h'+\frac{lh}{a}\times\epsilon$$

whence

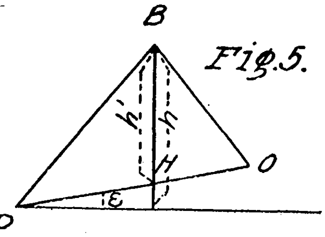
$$\frac{h-h'}{h}=\frac{\epsilon}{a}\times l=Kl,\ K \text{ being constant.}$$

[1] By drawing the wire to the side desired for a length equal to l; and by graduating it in $\frac{a\ b}{h}$ (an arrangement similar to that of the ribbon of the altimeter first described), the altitude can be directly read on the upper wire.

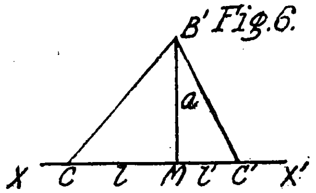
In other words, the altitude must be increased by a percentage which depends only on the position of the rider C on its rail.

The zones where the correction equals $\frac{\pm 2}{100}, \frac{\pm 3}{100}, \frac{\pm 4}{100}$, etc., will be painted on the rail in different colors. A glance at the position of the rider will therefore allow the reader to rectify the altitude reading.

Erection—Precision to be expected.—The rail $x\ x'$ can be put in a trench. Except the wire $y\ y'$, the whole apparatus is be-



low ground level. The altimeter will be good if the "altimetric roof" is truly in plumb. For this, it is sufficient that the wires $x\ x'$ be *horizontal* and truly *parallel.* Their horizontality and parallelism must be assured to within five-thousandths. The total obliquity of the wires $x\ x'$ on the base is unimportant so long as it does not exceed fifty-thousandths.



The altimetric roof being in plumb, the measurement of the separation of the slopes must be made on a parallel to the base placed below the wire at the given distance.

The parallelism of the rails $y\ y'$ and of the base need be assured only within fifty-thousandths. But these rails must be horizontal to within five-thousandths (posts at the same level). The difference of level between the slit and the wire $x\ x'$ should be exact to within one-fiftieth.

By means of these few precautions, and *for a base of 3,000 meters*, one can count on an average precision of 1/50 within the whole zone of action of the gun. Like all the " roof " altimeters, the string altimeter has no dead angle.

Compared with the zero-plane altimeter, the so-called "flag process" (supplement No. 2, the Arnouville course), it has the advantage (a) of having no dead angle; (b) of being less visible; (c) of not requiring so perfect simultaneity of the two sights taken at P and at O. In fact, calculation shows that without the altimeters an error of "top" of one second is unimportant (for a base of 3,000 meters). With the telemeters based on horizontal telemetry, if it is not desired to increase the dead zone more than necessary, the top must be exact to within $\frac{1}{4}$ second.

It has the undesirable feature of not appealing so directly to the eye, and of not lending itself so well to the observation of the bursts. We shall see, however, that it can be supplemented with a sort of "screen" which gives the error of the bursts in altitude.

II. Observation for Altitude.

In the note of May 22, 1916, on lateral observation (supplement No. 1, Arnouville course), the only question is of observation *for distance.* Corrections for altitude are viewed only as a circuitous means of obtaining the correct distance, a means which is introduced with the remark that the proportion $\frac{\Delta h}{h}$ is equal to $\frac{x}{D}$ (x being the error of range—see the note cited above).

Why this circuity? Why not try to measure the difference of altitude between the shell bursts and the aeroplane? Many officers have raised this question and have brought forward a number of advantages to be obtained from ranging by altitude—advantages to which we shall return. The following answer was given them:

First. Adjustment of altitude is not independent of adjustment of site. When the order "Up 20" is given, the range to the bursts does not change. If they have been at a good range, they remain at a good range. Their altitude changes—it increases 100 meters.

In mathematical language, we reply that the three coordinates, deflection, site, and distance, form an orthogonal system, and

that by using them the three adjustments to be made are independent.

Second. The methods heretofore proposed for adjustment for altitude are open to criticism.

The first objection is easy to remove. If the order "Up 20" is given simultaneously to the altitude telemeter and to the gun, *the altitude of the bursts does not change, but the range to the bursts does change.* This is naturally what happens in the case of the telemeter of the automounted light gun, since it is attached to the cradle. In regard to the independent telemeter, it is no more difficult to raise by 20 the corrections for site of the telemeter than to raise by 20 the corrections for site of the gun. In fact, it is not a simple thing for either, unless we can move the zero. But all the new telemeters have a movable zero. So, with the reservation that the same corrections be made for the telemeter and for the gun, the adjustment for altitude is independent of adjustment for height. A correction for site affects only the horizontal distance of the bursts. Horizontal distance, altitude, deflection—we have again an orthogonal system of coordinates.

Before removing the second objection it is worth while to develop it.

Old conception of observation for altitude.—Observation for altitude was conceived as necessitating a process similar to the "flag" process. In supplement No. 2 of the Arnouville course, the flag was considered only as an indication of errors *in distance* (bursts supposed to be about right in direction). But it is very evident that it is only necessary to compare the horizontal line passing through the aeroplane with the horizontal line passing through the shell burst to obtain the error *in altitude.*

Let us take the case of the flag, as the other processes proposed are derived from the same principle. With the flag, is it better to make the observation for distance or the observation for altitude? Calculation of the errors committed in the two cases gives the following results:

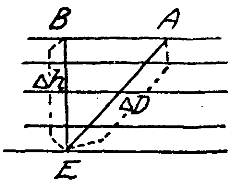
(*a*) *Ease of operation.*—On the plane of the flag the aeroplane is projected at A, the burst at E (fig. 7). The error for distance is $A\ E$; the error for altitude is $E\ B$.

Of these two segments $\Delta\ D$ and $\Delta\ h$, the easier to observe will be the one which will be seen at the greater angle. It will be shown in an appendix that the angle at which $\Delta\ h$ is seen is

smaller than the angle at which ΔD is seen when the aeroplane is on the side toward O, and larger in the contrary case.

In other words, it is precisely when it is hard to see, and when we must lend a hand to the distant observer No. 2, that the observation for altitude becomes easier than the other.

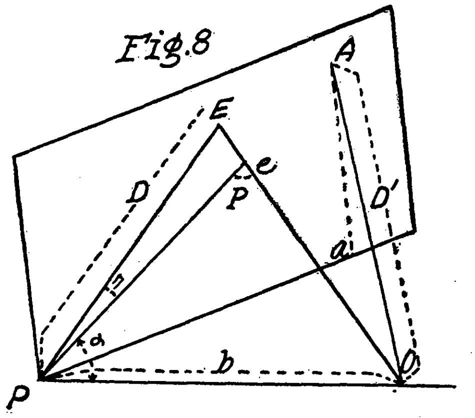
Fig. 7.



(*b*) *Influence of errors in direction* (fig. 8).

Notations.—E, shell burst observed by O; e, perspective of E in the vertical sighting plane which passes through the aeroplane η, angle $E\ P\ e$.

Fig. 8



The angular error η involves an error in the correction of altitude to be ordered, which is different according as the observation is made for distance or for altitude.

In the former case calculation shows that the error committed, e_a, is equal to $h\ \eta \cos p$.

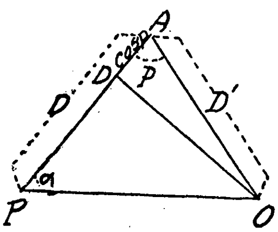
In the second case, the error committed, e_h, is equal to: $h\ \eta \times \frac{D}{D' \sin p}$.

The proportion $\frac{e_d}{e_h}$ has the value $\frac{D' \cos p}{D}$.

It is $>$ or $<$ 1 according as the angle α (fig. 9) is acute or obtuse.

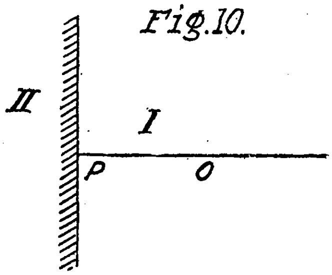
The curve of demarcation between zone I, where the error is greater for observation of altitude, and zone II, where it is

Fig. 9



smaller, will be the perpendicular to $P\ O$ which passes through P (fig. 10). In other words, observation for altitude gives larger errors than observation for distance when the aeroplane is on the side toward O; that is, precisely when it is easy to see.

Fig. 10.

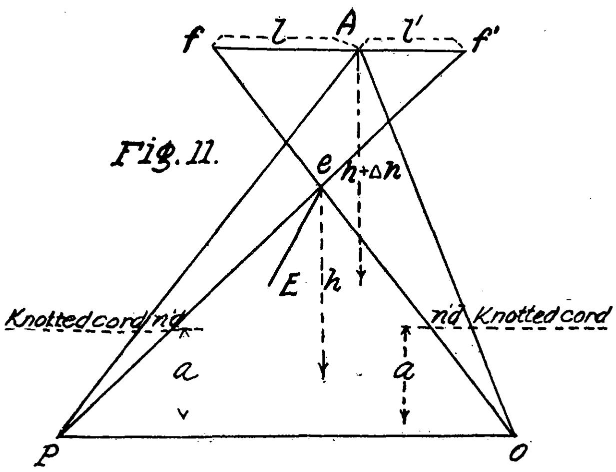


Paragraphs (a) and (b) above sum up the objections which have been made to the processes of measuring errors in altitude. We shall see that these objections can be partially removed by means of the flag process, thanks to the addition of a rake with *vertical teeth*, and completely removed by a new process, which we call the "conjugated-screens process," and which results in observation for altitude becoming the most advantageous.

MEANS OF CORRECTING THE ERRORS OF THE FLAG PROCESS.

Rake with vertical teeth.—This means is similar to that which was suggested in the note of May 22 on lateral observation. At the battery post a rake is installed, the height of which is changed proportionately to the square of the altitude. But, instead of orienting the teeth perpendicularly to the plane $P\ O\ A$, they are left constantly vertical (this difference is due to the fact that the angle η is not the same as the angle ϵ which the above-mentioned note had in view). The gimbal mounting for orientation becomes useless. By using this rake we get much less error in the case of observation for distance. The error will disappear when we use a rake *with corrector* of the

Fig. 11.



usual form, but with vertical teeth. The error is also completely done away with in the case of observation for altitude, and this is all in its favor.

But it is very true that, in both cases, when the aeroplane is near the base the rake with vertical teeth does not give good results. The teeth are seen at too small an angle.

Conjugated-screens process.—Let us draw through E a horizontal line perpendicular to the base $P\ O$ (fig. 11). It meets the plane $P\ A\ O$ at a point e, which has the same altitude as

E.[1] Let us suppose that the point e is a visible point, at which one may look by the usual process of the two conjugated knotted cords. Let n and n' be the number of knots reported by O and P. $(n+n')\times d$ (d being interval between the knots) is the measure of $ff'=l+l'$ on the scale $\frac{h}{a}$, that is to say $l+l'=\frac{h}{a}\times d$ $(n+n')$ ($\triangle h$ in relation to h is neglected).

But the similarity of the triangles $e\ f\ f'$ and $e\ P\ O$ gives—

$$\frac{\triangle h}{h}=\frac{l+l'}{b}$$

whence:

$$\triangle h=(n+n')\times\frac{d\ h^2}{a\times b};$$

that is to say, Δh is measured by $n+n'$, the scale of the measure being constant if a is proportional to h^2, and variable, but easily determined if a is constant. (For example, it will be known that a knot corresponds to 200 meters for altitude 3,500 and to 100 meters for altitude 2,500.)

We must now define the direction $E\ e$. For this it is evidently necessary to replace the cord by a horizontal screen formed by parallel wires stretched on a rectangular frame. The screen will be placed at altitude a above the eye. The wires will be orientated perpendicularly to the base. The separation of the wires will be calculated by the formula:

$$d=\frac{a\ b}{h^2}\times\triangle h.$$

If a is proportional to h^2, Δh will be taken$=a$ constant$=200$ meters.

If a is constant, Δh will be taken$=200$ meters when $h=3{,}500$.

This process is entirely similar to that of the conjugated rakes. The conjugated screens are, in fact, rakes whose teeth are always horizontal.

If the aeroplane is far to one side, the wires of the screen will be seen obliquely. The observation will be a little inferior to that with the rakes; but, on the other hand, the observation will always be exact, and it will not be necessary to add any correction to the screen of post P. The algebraic addition of $n+n'$ is sufficient.

---

[1] When we were making the observations for distance we replaced E by a point e, which was its projection on $P\ A\ O$, and which was therefore at the same distance as it was from the point P.

Simplicity of construction, simplicity of use—these advantages are so great that it is probable that the screen will replace its elder brother, the rake, as soon as we have altitude telemeters with movable zeros. The screens can be formed by 5 horizontal wires stretched perpendicularly to an observation trench parallel to the base (paramater a is in this case a constant). The wires and the trench must be long enough so that we can see the aeroplane projected on the wires without leaving the trench. A scale in beads on the middle wires and a metric scale along the trench permit of the immediate location of the aeroplane—the same process as for the string altimeter.

SUMMARY OF THE DISCUSSION.

Two great objections were brought against the adoption of ranging by altitude.

First objection.—Corrections made for site change the altitude.

This objection does not apply to the telemeter of the automounted light gun. Corrections of site on it change the distance and not the altitude. It applies only to the old field telemeters which were not equipped with movable zeros. It will no longer apply to the new telemeters nor to the old telemeters equipped with an independent site-registering device.

Second objection.—The second objection was relative to ease of observation, and especially to the errors to be anticipated. It is done away with by the use of the conjugated screens, and it turns in favor of the observation for altitude in the sense that, though the screens give a rather less precise observation than the rakes with corrector, they are much more simple to set up and much more simple to use.

There remains in favor of observation by altitude an advantage which has long been known. This advantage is the following: Errors in the correction of site, whether due to our own mistakes or to the aeroplane not moving in a straight line, have no influence on the altitude of the bursts, since they affect the gun and the altimeter at the same time (except in the case of the aeroplane changing its course during time lost between observations and in the case of an error in calculating this time lost between observations).

With the observation for distance, it was not necessary to take account of the errors in range which might be due to a

change of course of the aeroplane. With observation for altitude, the only evolutions of the aeroplane which can throw us out are those which occur during the time lost between observations.[1] This advantage is of prime importance.

Our conclusion is the following: Observation for altitude is obligatory when using the telemeter of the auto-mounted light gun. Provided it is made with the aid of a precise process, such as that of the conjugated screens, it seems to us the best for posts which have available a ready means of giving the telemeter the same corrections for adjustment as are given the gun (movable zero or independent sitogoniographs). In the contrary case we should continue to apply the old method of observation for distance.

ADJUSTMENT OF TRACER SHELL.

Use the process of the two conjugated knotted cords. For the two posts, the point to be observed is the apparent intersection of the trajectory and the cord. In this way is obtained the altitude of the point of intersection of the trajectory and of the plane P O A, an altitude which is nearly the same as that of the point of intersection of the trajectory and the plane of the site. At night light up the cord, or at least the knots of the cord, by some process. For example, it can be replaced by a small opaque tube through which light is sent and which allows the light to escape by a series of equidistant slits.

APPENDIX.

I. COMBINATION OF THE STRING ALTIMETER AND THE SCREEN.

(Process under study, proposed by Capt. Bricard.)

It seems easy to combine the principles of the string altimeter and the screen. At each of the posts P and O the single wire $y\ y'$ is replaced by five parallel wires, the intervals between the wires corresponding to 200 meters of correction of altitude for h=3,500. On the rider C' draw five lines, separated

[1] Of course, in the case of evolutions in altitude, the mean must not be taken between the error which has just been observed and the errors observed previously. The latter errors refer to an altitude different from the present altitude.

by the same interval as the wires (fig. 12). It is understood that an interval represents 10 (10 times 20 meters for $h=3{,}500$). At the burst of a round the two sighters of the altimeter report the errors as usual. For example, O reports "Short 30" (3 intervals); P reports "Over 15" ($1\frac{1}{2}$ intervals). The bursts are 15 short.

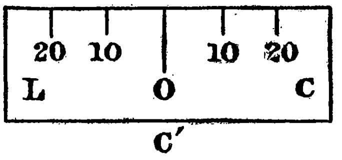
The reader of the altimeter at once reads on the graduated ribbon of the altitude, with the aid of the scale on the rider, the error of altitude which corresponds to 15.

We can also prolong the sighting slit to such a length that two observers can watch at the same time, one watching the aeroplane and the other the bursts. The latter sees the error of the bursts without having to pay any attention to the aeroplane, which results in greater exactitude.

These two processes are still under study.

The first process would permit a saving of personnel, but on condition of giving up the continuous measurement of the altitudes, which is not unobjectionable.

Fig. 12.



If the true altitude is measured almost continuously, the observation gives the "ballistic error" increased by the variation of the true altitude during the time of flight of the projectile. By the algebraic addition of the total thus observed to the true altitude a sort of interpolation is made which, to a certain degree, takes account of the slope of the route followed by the aeroplane (in short, the variation of the true altitude during the time of flight of the projectile is taken twice).

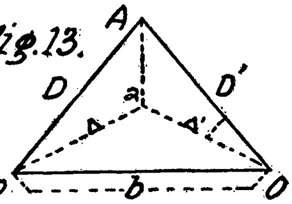
If, on the contrary, the measurements of altitude are taken at intervals longer than the time of flight of the projectile, these measurements are no longer of any use. The variations of altitude which they show apply to too long a period. To add them to those which the observation has already brought to

light would be the same as to suppose that the aeroplane is going to gain or lose as much height during the time of flight of the projectile as it lost or gained during the time which separated the two measurements.[1] The altimeter no longer serves except for giving the altitude at the instant of discharge. It then becomes a question of ranging, and, if it is desired to interpolate the altitude, this must be done by judgment, guided either by the apparent evolutions of the aeroplane or by the assumption that the series of errors on which one decides goes on regularly increasing or decreasing.

II. EASE OF OBSERVATION BY THE FLAG METHOD IN OBSERVING FOR ALTITUDE OR FOR DISTANCE.

(Development of the considerations suggested in paragraph (*a*) of "Observation for altitude," above.)

Fig. 13.



In figs. 7 and 13 let $\omega\ d$ be the angle at which ΔD is seen, $\omega\ h$ be the angle at which Δh is seen, D' the distance $O\ A$, Δ' its horizontal projection, Ψ the angle of the plane $P\ A\ O$ with the horizontal. The calculation gives:

$$\frac{\omega d}{\omega h} = \frac{b}{\triangle' \sin \psi}$$

In horizontal projection the curve which separates zone I, where observation for distance is easiest, from zone II, where the observation for altitude is easiest, is defined by:

$$b = \triangle' \sin \Psi$$

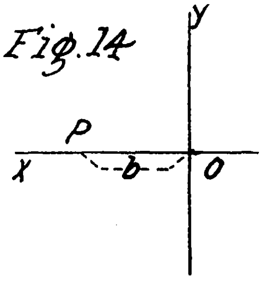
[1] These considerations permit the definition of what we call an altimeter giving altitudes in a continuous manner. It is an altimeter which gives them at intervals distinctly shorter than the time of flight.

Referred to the axis OP and a perpendicular axis passing through O, it has for equation:

$$\frac{x^2}{b^2}+\frac{v^2}{\frac{h^2b^2}{h^2-b^2}}-l=O.$$

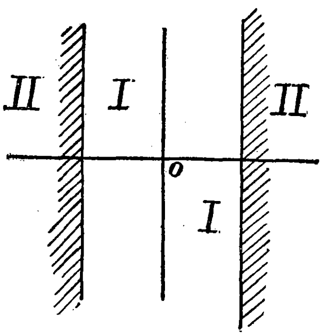
If $b=h$, this curve is a system of two right lines perpendicular to $P\ O$ and having for abscissa $\pm b$ (figs. 14 and 15).

Fig. 14



If $b>h$, zone I increases at the expense of zone II. The curve is a hyperbole (fig. 16).

Fig. 15.



If $b<h$, zone II increases at the expense of zone I. The curve of separation is an ellipse (fig. 17).

The case of $b=h$ being an average case, it may be said that in general observation for altitude is easier when the aeroplane is far from O.

Fig. 16.

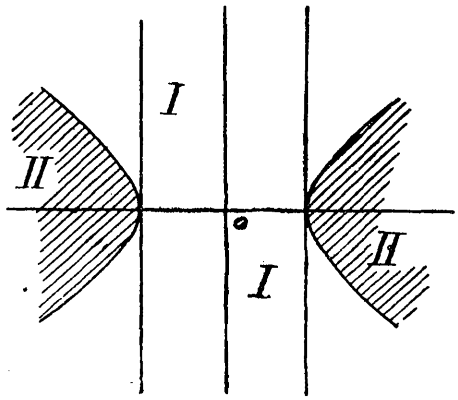


Fig. 17.